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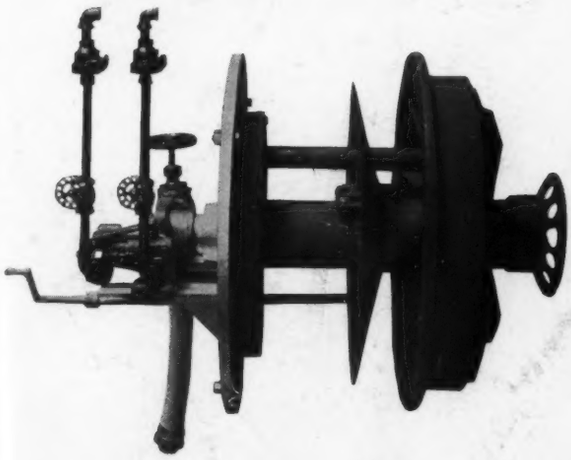

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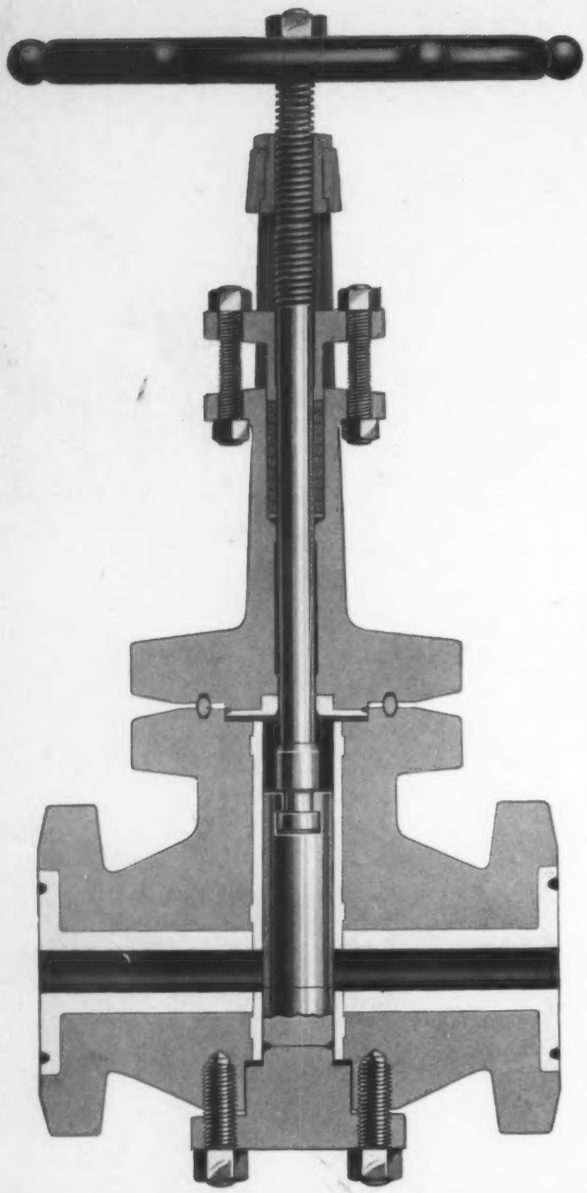

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REFINER
AND NATURAL GASOLINE MANUFACTURER

AUGUST, 1933
Vol. 12, No. 8

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Editor

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CONTENTS

Special Features

Modernization Economic Necessity 297
An Editorial

Globe Plant Typical of Modern Design Trends 298
J. C. Albright

The Burning of Refinery Wastes 310
V. R. Chadbourne

Precision Calorimetry for Gases 315
W. F. Fulton

The Refining of Vapor-Phase Cracked Gasoline 321
W. H. Thomas

The Nitrobenzene Process for Lubricating Oils 328
S. W. Ferris and W. F. Houghton

Combination Refining Plant at Whiting Unique in Modernity .. 333
J. V. Jirasek

Transition from Shell to Tube Still Not Yet Complete 335
George Reid

Cleaning Refinery and Gasoline Plant Equipment 340

Regular Departments

Editorial 297

Science and Technology 36a

The Month in Review 45a

Plant Activities 53a

New Equipment for the Modern Plant 55a

Items About Manufacturers 58a

Catalogs and Bulletins 59a

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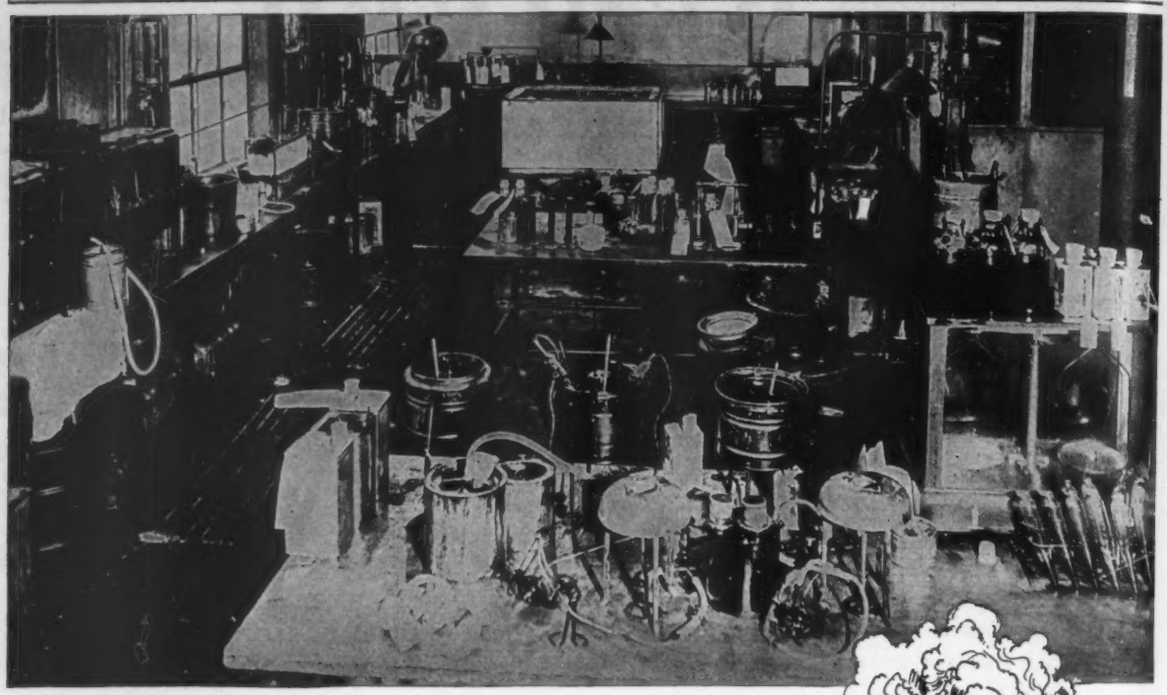

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REFINER
AND NATURAL GASOLINE MANUFACTURER
A Gulf Publishing Company Publication

VOLUME 12, No. 8 AUGUST, 1933

Modernization Economic Necessity . . .

FACED with a popular demand for 65 to 70 octane rating motor fuel, with a trend toward increasing octane rating of third grade gasoline, and with a surplus of low priced fuel oil, the refiner finds it an economic necessity to maintain his cracking department in efficient operating and producing condition.

There are those who see increases in sales volume of third grade gasolines as retail prices of premium and regular motor fuels become inevitably higher. That market may become more competitively important as quality is improved. Resumed industrial activity and winter months should bring about improvement in fuel oil demand and prices, but no condition can be foreseen which will change the economic situation sufficiently but that the best thing to do with fuel oil is to crack it.

Ever varying market conditions largely control the economic situation of the petroleum industry. The profits to be derived from refinery operation are directly dependent upon the plant equipment and its flexibility. Processing facilities must possess sufficient flexibility to meet demand and specifications of those products which are most profitable to produce at the time. Market conditions will continue to vary.

On the other hand there is the problem of competitive operations of units within the industry. Each unit in the plant yard must be continually and progressively changed to incorporate new features resulting from technical development. Progress in design, construction, operation, new processes and developments, continue to render older operation obsolete from the standpoint of efficiency. Old equipment finds it ever increasingly difficult to compete with its modern neighboring installations.

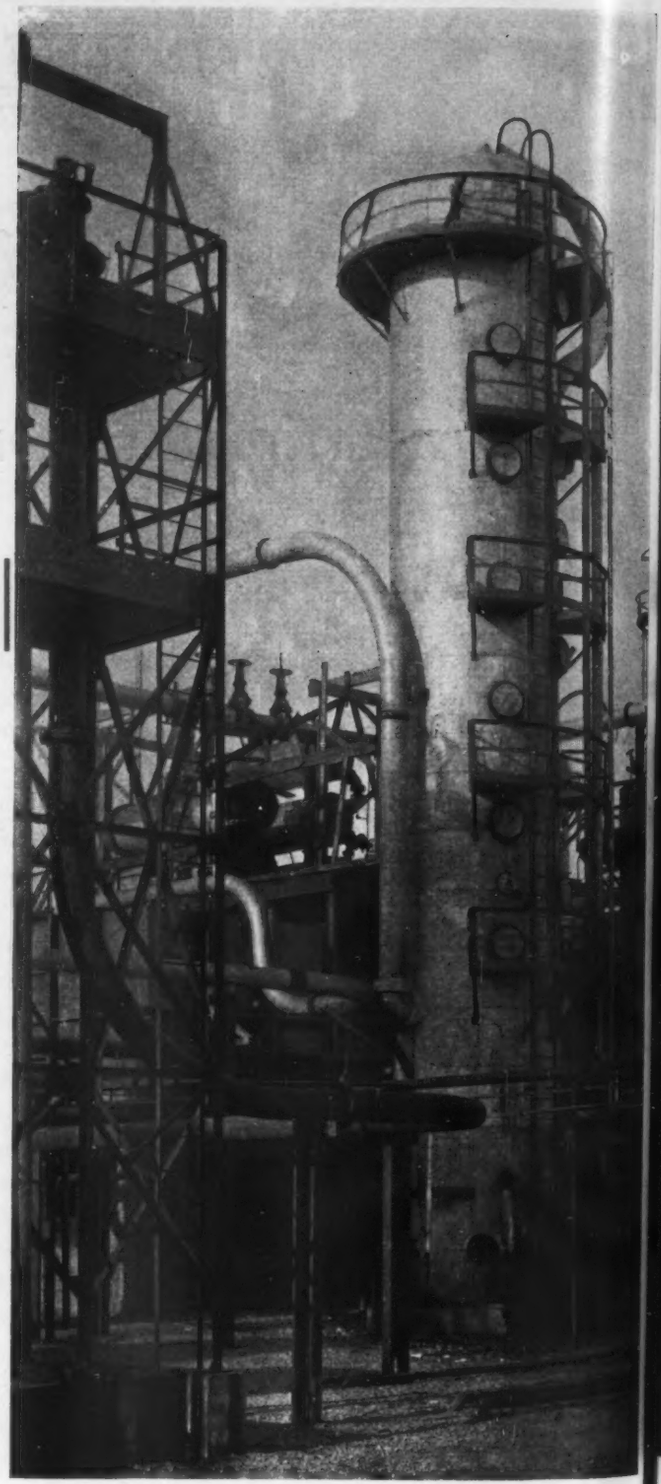
In straight distillation of crude oil it is estimated that 50 per cent of total crude charged is run through batteries of old-fashioned shell stills. Modern tube stills handle the other half. The transition to modern facilities will gain impetus with better times. In cracking, 25 per cent of available capacity is shutdown and conservative estimates place 15 per cent permanently inoperative. The industry is adequately equipped, from the capacity viewpoint, to take care of present needs and any improvement in demand, but it is not equipped with sufficient scientifically designed refining facilities to do so at a profit. The percentage of obsolete equipment is much too large.

Trade practices and education of the motorist has brought about a condition where present quality of motor fuels must be maintained. Refining facilities of the industry are inadequate for the job. The present activity in construction of all types of refining units, straight distillation and cracking, and such additional installation work as will be carried out in the next few years, is not for the purpose of expanding already over-built capacity.

Much additional installation of equipment is necessary, however, because the various manufacturing units within the industry must compete in efficiency of operation and therefore must take advantage of technical developments and progress. Technical development and progress coupled with particularly rapid obsolescence accelerated by the severity of the service, brings the individual refining company constantly face to face with the question, does the plant equipment and processing facilities possess sufficient flexibility to meet varying demands of changing market conditions and can it compete with newly developed features in existing systems or with newly developed processes?

Globe Plant Typical of Modern Design

J. C. ALBRIGHT

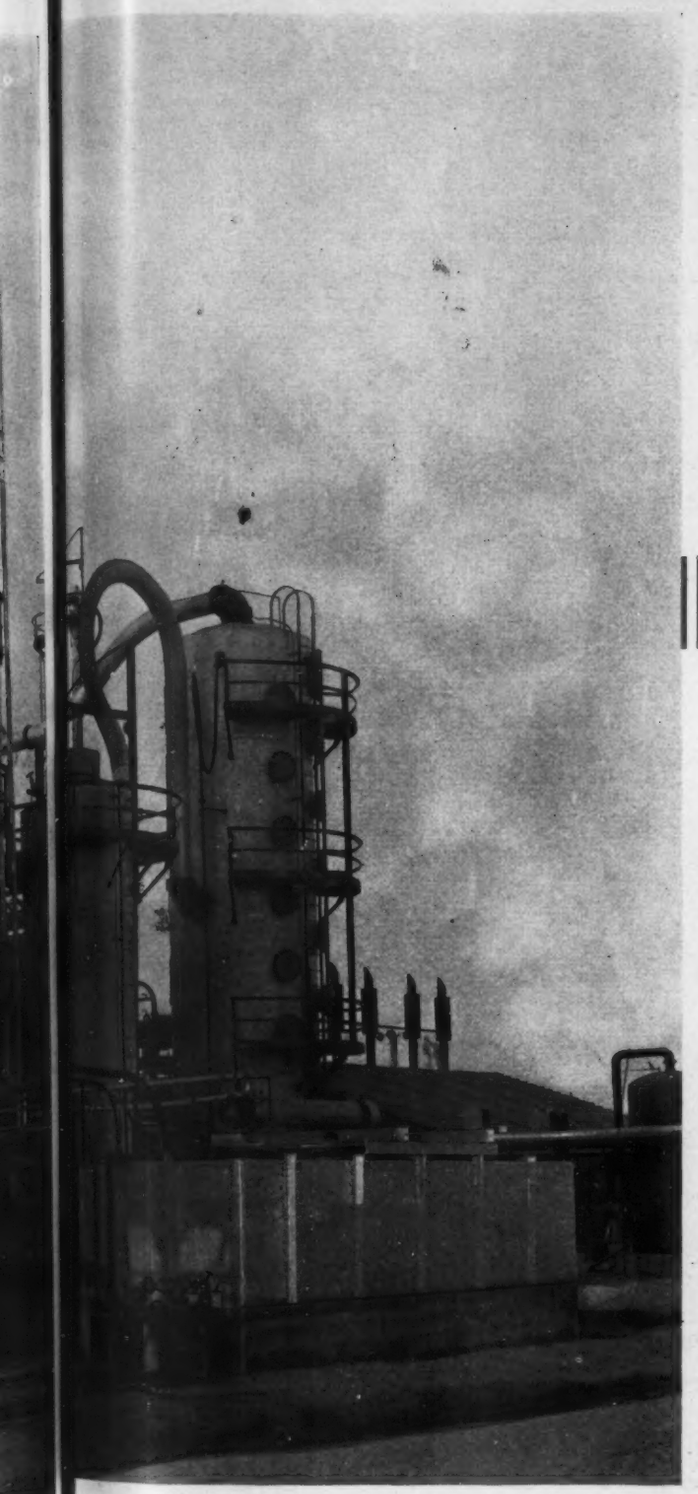


GLOBE OIL & REFINING COMPANY began operating its Winkler Koch combination skimming and cracking plant at McPherson, Kansas, March 1, 1933. This complete unit designed to process McPherson County crude oil through all the phases necessary to provide a complete distillation producing motor fuel, kerosene and fuel oil, embodies several features of interest. First, the cold crude is stabilized, or debutanized with exchanger heat as well as being skimmed of all the lighter fractions contained in the charge before any part is subjected to heat by being passed through pipe stills. Second, those fractions adapted to cracking are passed in a continuous stream through the furnaces containing acquired heat in the skimming process. Third, the vapors from the cracking units are led directly while hot to the Lachman zinc chloride vapor phase treating unit. Fourth, all light gasses not condensed in each process are led to a recovery plant. All products intended for marketing, except fuel oil, are pumped continuously as manufactured through final treating units for sweetening before being loaded for shipment.

The crude charged to this combination unit has a gravity of 38-5 to 39.1° A.P.I. Picked up from the plant tank farm storage, consisting of Graver riveted 55,000-barrel steel tanks, by a National duplex reciprocating steam pump, 14x10x14-inch, the oil is fed at 14 strokes per minute to the crude stabilizer, or debutanizer. The first contact with heat occurs in passing through Westinghouse heat transfer units in the Lachman zinc chloride vapor phase pressure distillate treating system. There a temperature of 285°F. is applied to the charge. Passing from these units, the crude is led to a water settler, a horizontal drum, 7x24 feet, set at the base of the crude debutanizer, column. The hot crude enters this dehydrator through the upper shell near one end, passing through and emerging at the other, and is fed at 35 pounds to the column above the stripper plates. Butane and other light fractions released from the raw charge rise through the fractionating section and are removed as the overhead product. Continuing through a shell and tube condenser, these light fractions are condensed, a portion of which is pumped back as reflux. This product has a gravity of 89° A.P.I. and a fluid temperature of 80°F. It is removed from the accumulator drum and placed in a common surge tank to be processed with the product of the vapor recovery plant.

The bottom of this tower, 5x54 feet, is maintained

New Lachman System Has Novel Features



at 280°F., while the top is carried at 170°F. Stabilized crude drawn from the base of the column under a pressure of 35 pounds is picked up at this point by a National duplex steam pump, 14x9x20-inch and discharged to a closed coil placed in the top of the vapor separator, used both for dry trimming of the vapor separator and for transfer of heat to the debutanized crude charge. A temperature of 575°F. is applied to the oil in this section against a vapor separator top temperature of 665°F. The hot oil in process is then led through insulated piping to the flash tower, 9 feet by 93 feet, six inches, entering above the five stripper plates, where the charge is broken up into gasoline, naphtha, kerosene and gas oil, with reduced crude removed from the base.

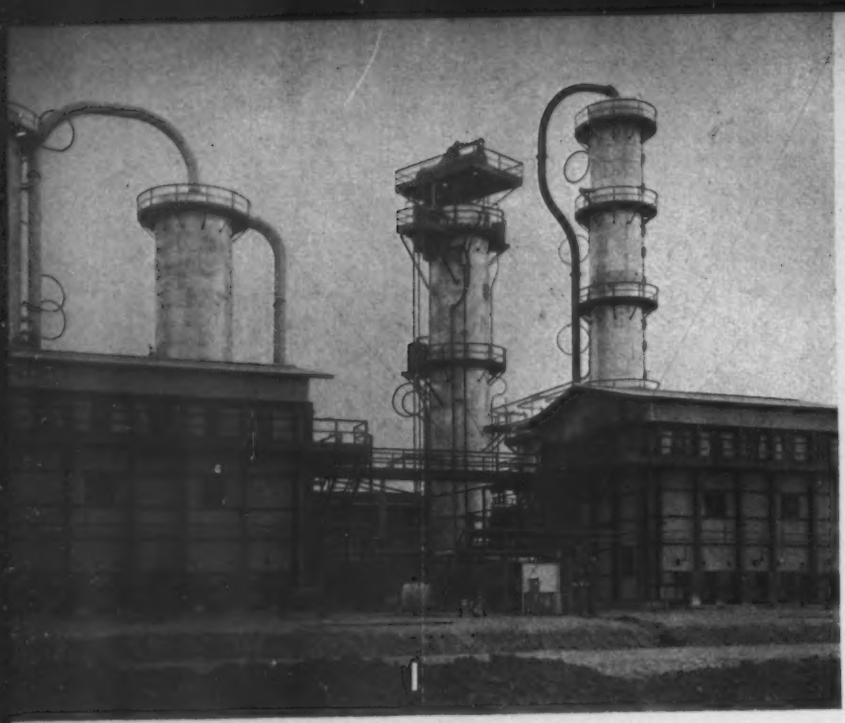
STRAIGHT-RUN GASOLINE

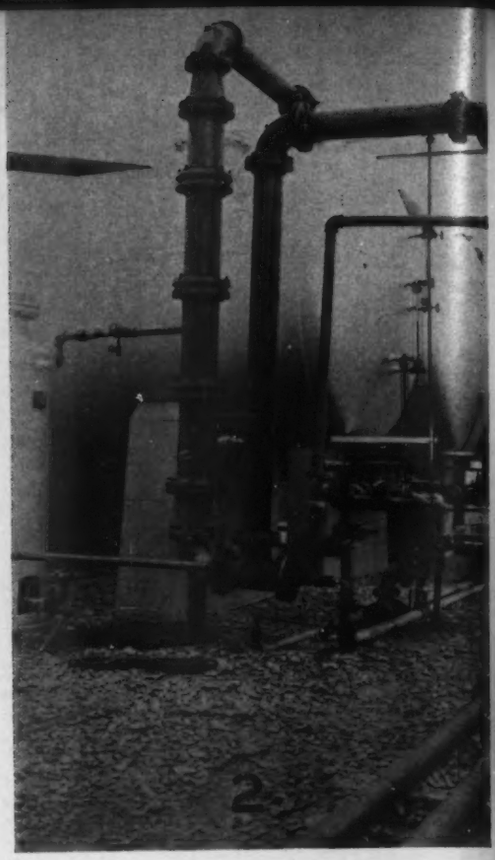
Overhead from the flash tower is condensed as straight-run gasoline having a gravity of 65° A.P.I. The top of the tower is maintained at 235°F. by refluxing back over the tower a portion of the condensed straight-run product of the following characteristics:

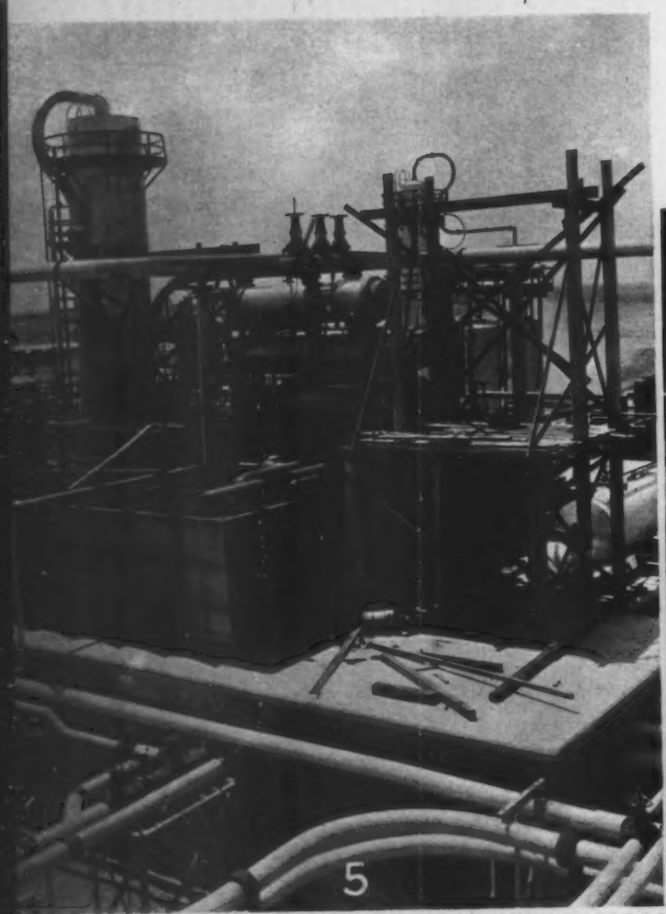
Gravity	65° A.P.I.
I. B. P.	108°F.
10	179°F.
20	215°F.
30	242°F.
40	264°F.
50	287°F.
60	306°F.
70	320°F.
80	320°F.
90	335°F.
95	352°F.
E. P.	380°F.
Color	30+
Distillation loss	1%

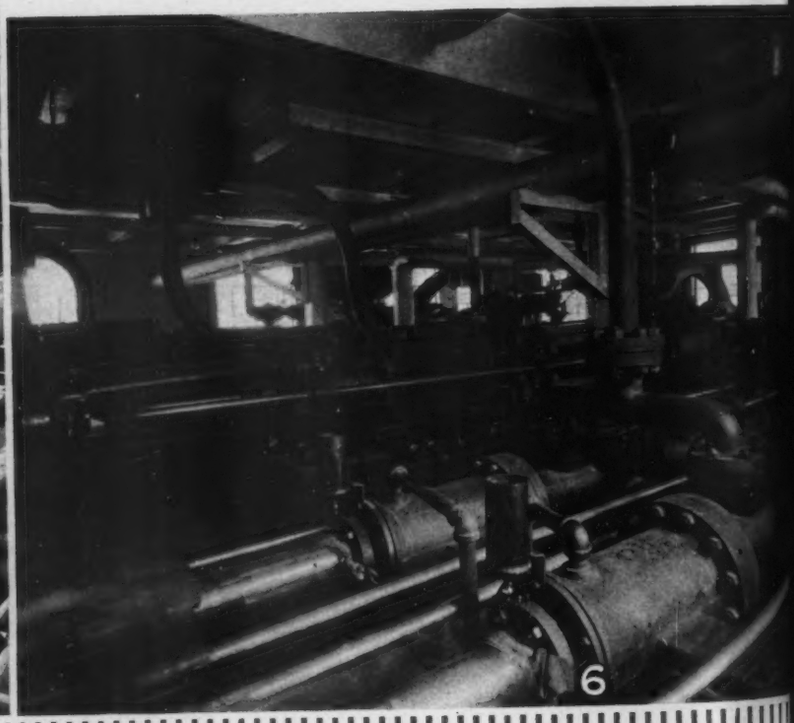
The flash tower is provided with three side streams to take off, naphtha, kerosene and gas oil. The naphtha section is maintained at 320°F. by refluxing a part of the product accumulated in the naphtha reflex drum back to the section from which the product is removed. The section from which the kerosene is removed is maintained at 450°F. and the gas oil or distillate section is operated at 545°F. All three products are led to stripper towers when first removed from the flash tower, each stripper being 4 feet by 18 feet, 6 inches in dimensions.

Bottoms from the flash tower, which is reduced









Globe Oil & Refining Company's Re

1—Cracking and reforming stills with vacuum tower in the middle distance. 2—Contact column for mixing chemicals at continuous treating system. 3—Foster-Wheeler steam superheating installation. 4—Control instrument panel in main control room.

3

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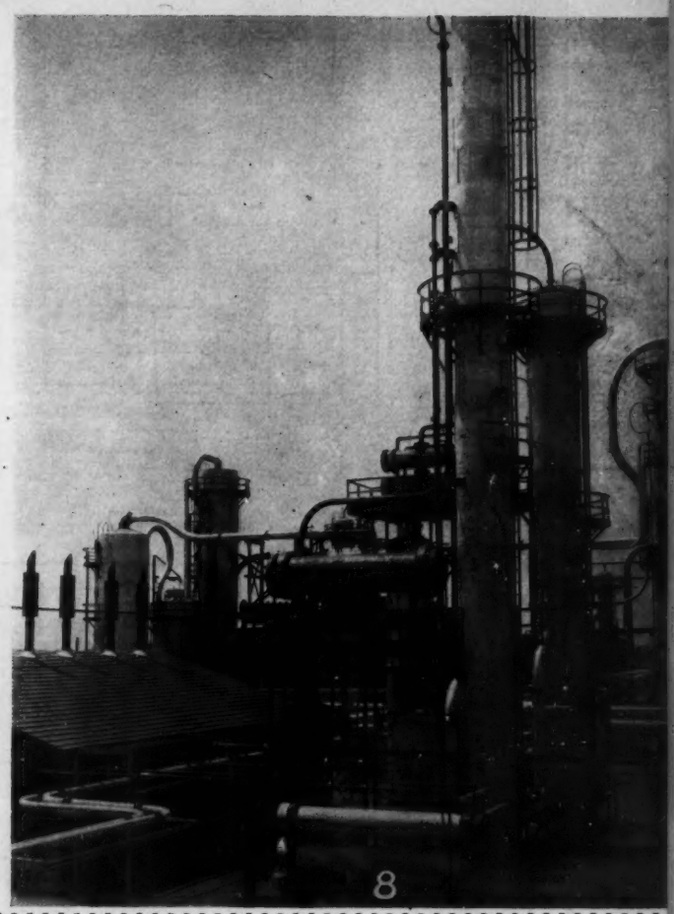

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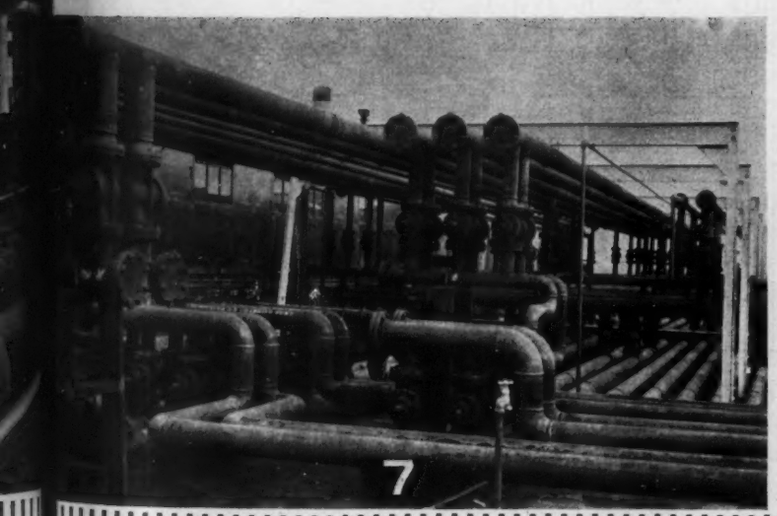
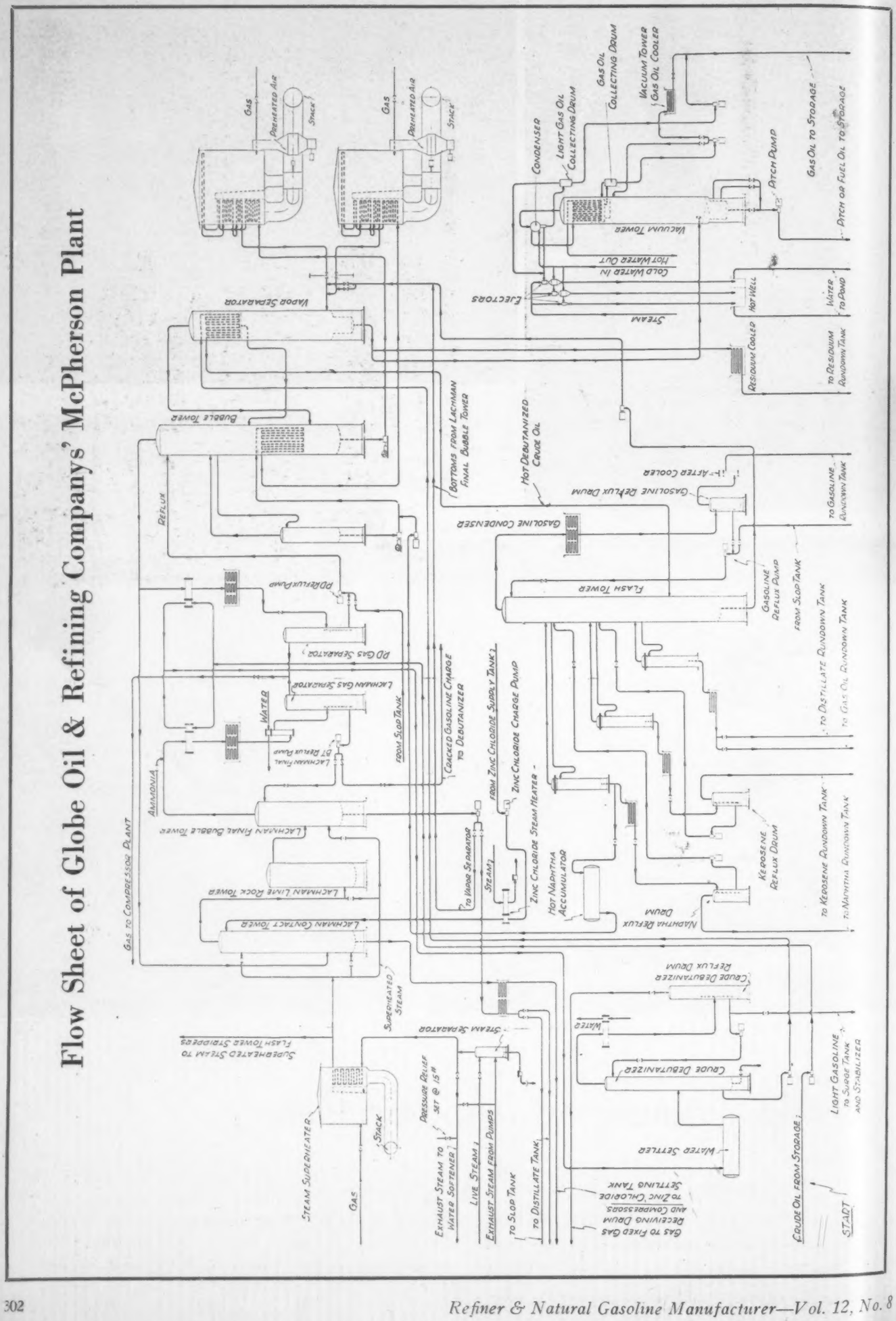


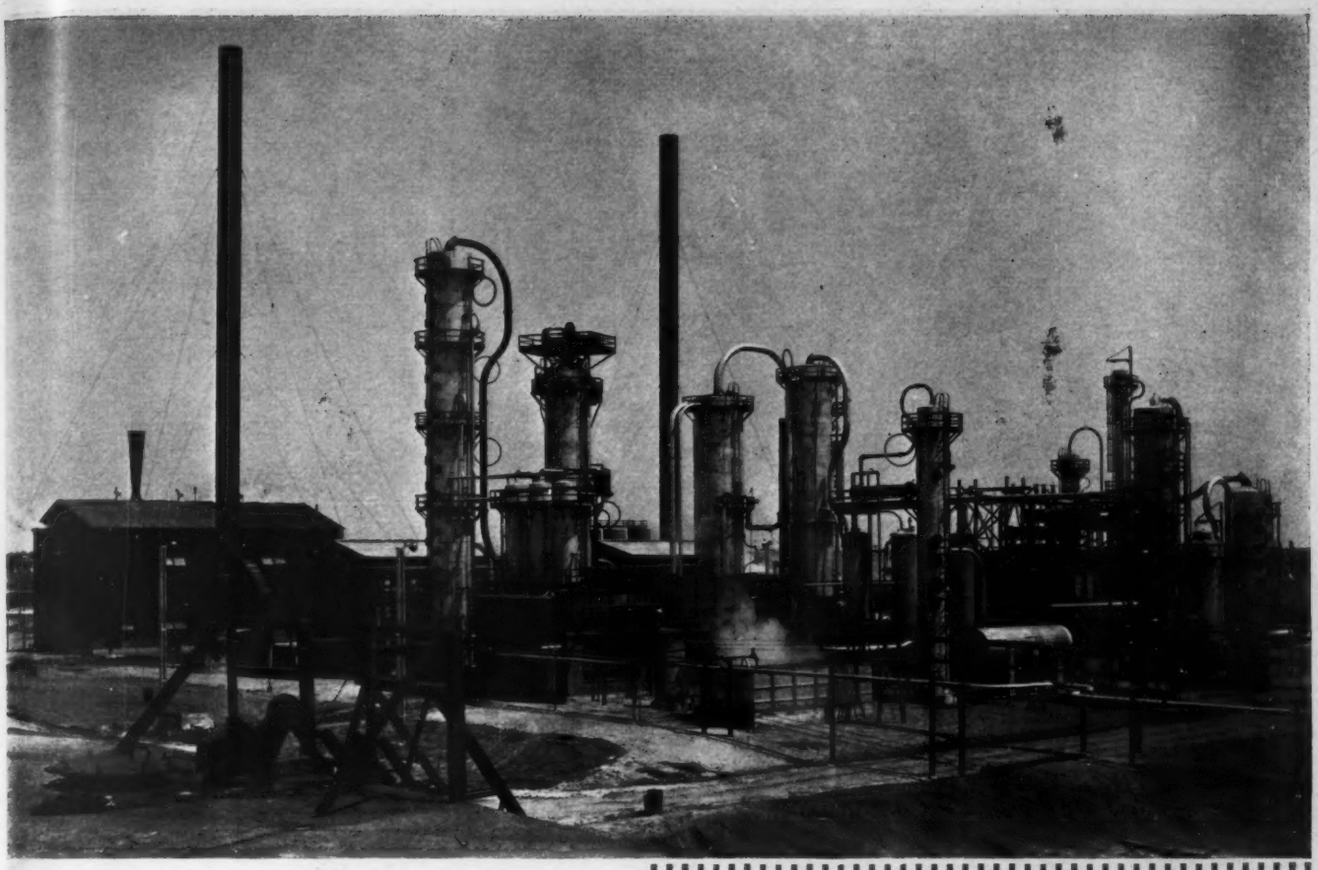
7

Recently Completed Modern Plant

5—Condenser installation and battery of heat exchangers. 6—Interior cracking system pump house. 7—Manifold layout outside of main transfer pump house. 8—Recovery and stabilization system.

Flow Sheet of Globe Oil & Refining Company's' McPherson Plant





General view of Vinkler-Koch installation.

crude having a gravity of 22.5° A.P.I., are fed to the cracking unit through a National 15x8x20-inch duplex pump as quench oil.

In the process, bottoms are picked up from the base of the bubble tower, a column 11 feet in diameter by 75 feet high, by a Worthington crank and flywheel pump, 16½ x 38x5¼x27-inch and discharged under a process pressure of 760 pounds. This material is handled without cooling and carries a temperature of 600° F. at the pump suction. Five tube sections are provided in the furnace, four in the wall and one roof bank using Globe Steel Tube Company tubes. The temperature of the furnace is maintained at 1420°F., with the roof tubes imparting a temperature of 910°F. to the oil in process. Outlet temperatures in the transfer line run at 925°F. with the pressure running at 400 pounds. Both the cracked charge passing through the furnace tubes and the hot reduced crude is flashed to the vapor separator through a common line, entering near the base at a pressure reduced to 47 pounds. The material entering the vapor separator has a temperature of 740°F., and under the pressure mentioned, separation of the fractions is accomplished.

Overhead fractions are admitted to the bubble tower near the base, with a side cut removed from a draw-off pan placed below the internal tube heat exchanger through which the crude is passed during skimming operations. This fraction is also admitted to the bubble tower, but at a point above an internal tube pre-heater through which the naphtha charge passes as it is being pumped to the reforming furnace. Dry refluxing of the vapor separator is accomplished by passing the crude in process through the closed coils in the top of the column.

TWO CUTS FROM TOWER

Two cuts are removed from the bubble tower, one overhead as combined pressure distillate and reformed naphtha, and the other as a side stream received in the high pressure side stripper, a vessel 5 x 31 feet which receives the high pressure stripper bottoms having a gravity of 24.5° A.P.I. and furnishes a part of the feed to the reforming coils in the furnace. Overhead material is the pressure distillate and passes out at 395°F. to the Lachman zinc chloride treating unit. However, a part of this stream is liquefied and used as reflux; pumped back over the bubble tower to maintain an end point of 395°F.

The bottoms of the high pressure stripper and the straight-run naphtha are fed to the reforming unit. The stripper bottoms are handled by a Worthington crank and fly wheel pump, 13½ x 30 x 4⅜ x 21 inches, and the straight-run naphtha is pumped with a National steam pump, 16 x 5 x 11-inches, both streams combine and pass through the preheater coil in the interior of the bubble tower. Naphtha of a gravity of 50° A.P.I. and the high pressure stripper bottoms with a gravity of 24.5° A.P.I. leave the internal exchanger with a temperature of 500°F. and enter the

Compressor plant at vapor recovery installation.

reforming furnace under a pressure of 600 pounds. This furnace is similar in construction to the cracking furnace, having five tube sections, four in the wall and a roof bank. In both furnaces, headers and return bends were furnished by Locomotive Finished Material Company. Reforming furnace temperature is maintained at 1325°F. The first preheater outlet runs at 675°F., the second at 745°F., the roof bank outlet at 960°F., and the transfer line or hot oil outlet is carried at 980°F. The product leaving the furnace is maintained under a pressure of 400 pounds and flashes into the vapor separator together and with the material under process from the cracking furnace.

The bottoms from the vapor separator are passed to the vacuum tower, a vessel 10 feet in diameter by 70 feet in height equipped with three-stage Westinghouse ejector. The process in this unit is to further reduce the bottoms to any heavy product desired, hard, brittle pitch if necessary, but the residuum coming from the base of the tower under present operations carries a gravity of 8.5° API. An overhead and a side cut of light and heavy gas oil is taken from the tower, the light product from the condenser on top of the tower, and the heavy from a trap-off plate in the upper section. Condensation of the heavy cut is accomplished with water-cooled internal coils placed in the tower carried at 585°F. The top is maintained at a temperature of 275°F., while the bottom operates at 600°F. Both the side and overhead cut of gas oil are blended together after the side cut is cooled and the product placed in gas oil storage.

LACHMAN PROCESS

The pressure distillate in the vapor phase, a combination of the products derived from cracking the reduced crude and gas oil and the vapors produced from the reforming process applied to the plant naphthas, pass into a treating system which is entirely new to the Mid-Continent. The Lachman process employing zinc chloride was developed on the West Coast by Dr. Arthur Lachman and the first installation placed in operation in the Richfield Oil Company refinery at Watson, California. This installation was elaborated and another unit built, but both were used in treating pressure distillate after it had been re-run. The installation built in the refinery at McPherson is placed directly on the stream of vapors coming from the Winkler-Koch bubble tower, and processes this product while hot and without re-running. This unit consists of two divisions, the contacting and fractionating equipment and the zinc chloride storage, reconditioning and settling tanks.

As the pressure distillate, the combined vapor product of cracking and reformed naphthas, leaves the bubble tower, it is led directly to the first tower in a series of three in the Lachman system. A 16-inch line connects the two, and a part of the vapors are con-

densed to be used as reflux over the bubble tower to control the end point of the pressure distillate vapors. The first column in the zinc chloride treating system, called the contact tower, is a vertical unit eight feet in diameter by 55 feet in height with only a short skirt between it and the concrete foundation. The tower, manufactured from half-inch tank steel, contains 14 bubble trays, each tray fitted with 21 caps. Both tray and caps are manufactured from a bronze with 85 per cent copper, 10 per cent zinc and the other five a combination of lead and other metals. The column is completely lined throughout the interior, shell, and heads, with sheet copper having a thickness of one eighth-inch. This construction, copper and bronze, was placed in the tower to prevent corrosion of the column shell. Hypochloric acid is formed in the contacting process, and being low in concentration, it will attack ferrous metals.

As the overhead temperature of the cracking and reforming system bubble tower is maintained between 395 and 400°F., so that the end point of the pressure distillate still in the vapor phase will have an end point, upon condensing, of around 410°F. and as the vapor line is insulated, those pressure distillate vapors enter the contact tower of the Lachman system carrying approximately the same temperature. The entrance flange to which the vapor line is connected is placed at a point above the first bubble tray, with the 20 trays above used as contact plates. Two points are provided for the admission of steam; one near the base of the contact tower, and the other below the upper three plates. Three different supplies of steam may be fed to the column—superheated, saturated, and exhaust from the pumps. The zinc chloride, a solution of 50 per cent concentration, is fed to the column beneath the upper three plates and may either be heated or injected at atmospheric temperature. As the plant is now operating, the zinc chloride is fed hot and superheated steam is utilized. The system pressure is continued with intentional reduction, and the contact tower top pressure averages 47 pounds as against the top pressure of the bubble tower in the cracking system of 49 pounds. Steam with a temperature of 465°F. superheated in a Foster Wheeler unit, is used under a furnace pressure of 57 pounds.

STEAM COUNTERACTS TEMPERATURE DROP

Contacting of the vapors with the zinc chloride causes a drop in system temperature which, if permitted to continue, would cause some of the heavier ends in the vapors to condense in the tower. To prevent this, enough steam is injected with the vapors to sustain the inlet temperature. Also, a drying effect is set up by the hot hydrocarbon vapors passing

National pumps and McCord lubricators. Johns Manville insulation in treating pump room.

through the zinc chloride, and to provide a solution still fluid, the admission of steam is governed by this situation also. By supplying superheated exhaust steam, the fluidity of the treating solution is maintained, and the temperature of the vapors leaving the contact tower is raised slightly. Once each eight hours the spent solution remaining in the base of the contact tower is drawn away and placed in one of the spent solution tanks provided for this purpose and situated in the second section of the treating plant.

After being contacted with the zinc chloride in the first tower, the vapors leave through an overhead line, also insulated, to the second section of the plant. This unit, called the lime rock tower, is eight feet in diameter by 37 feet high, constructed of one half-inch steel. The interior of this tower is lined from base to top with acid proof tile. Limestone as it comes from the quarries is placed in the column, the pieces of rock varying in size. A man hole, through which the lime contents of the column may be replenished as necessary, is situated in the upper head.

Steam may be injected into this lime rock tower along with the vapors from the contact column, both entering near the base in order that the vapors may contact the lime the full length of the tower. The temperature of the vapors in the rock tower is approximately the same as when they entered the contact column, and the pressure drops only 12 pounds in traveling through the two contactors.

TREAT WITH LIMESTONE

This tower, filled with limestone when the refinery was placed in operation, was expected to operate over a period of four or five months before replenishing the rock charge. An inspection of the interior of the column will give the operator an indication of the condition, and as the mass of rock disintegrates, all that is necessary is to replenish the stock by filling the column to the original point by the addition of fresh stone. The purpose of this unit is to neutralize the acids carried with the pressure distillate vapors and formed while in contact with the zinc chloride. Contacting with the limestone in the column, hydrogen chloride is removed and calcium chloride falls to the compartment in the base of the column and is drawn away as sludge.

Vapors in the lime tower are removed through an opening in the side of the shell near the top, and carried through a 12-inch insulated line to the third column in the series. This column, termed the final bubble tower, is a vertical shell nine feet in diameter by 42 feet high and contains 12 bubble trays. The ordinary construction was carried out in the fabrication of this tower, but the bubble caps are made of cast iron. The entrance of the pressure distillate vapors to this column is above the lower four trays which are used as strippers. Steam may also be admitted to this tower for process purposes, entry being at the base to provide agitation and to separate the lighter fractions from the polymers.

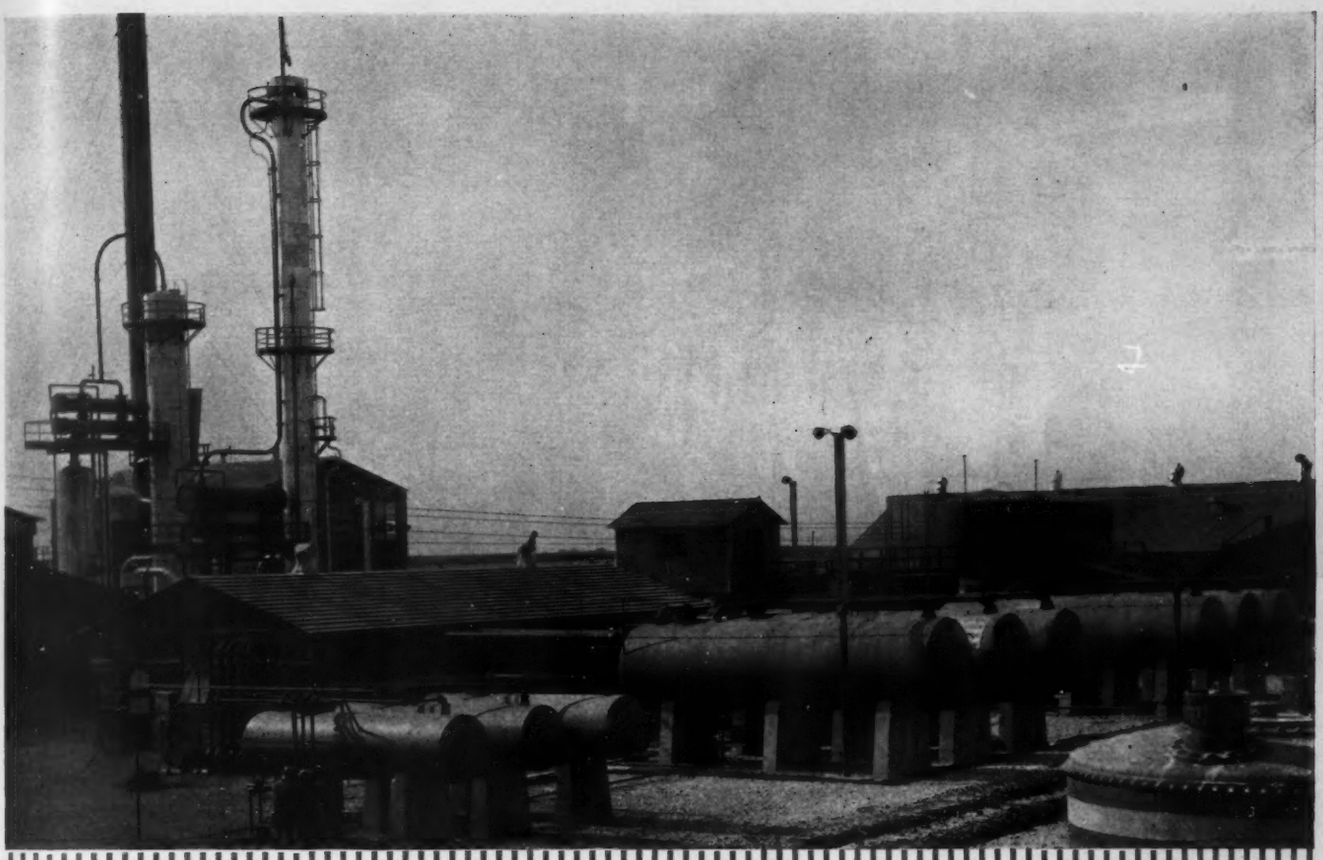
Leaving the upper head of the final bubble tower, the fractionated vapors are led to the exchangers and final condensers. A line in the overhead line near the outlet of the vapors from the tower carries anhydrous ammonia to effect a further removal of the acids which are not separated from the hydrocarbons by the action in contact with the limestone in the rock tower. As the vapors are carried from the final fractionator, the line in which they travel is connected to a series of Westinghouse heat exchangers in counter current flow to the fresh cold crude in process from the storage tanks to the crude stabilizer or debutanizer.

Below these exchangers is the condenser tank which contains submerged pipe coils in which the pressure distillate is liquefied. From them the distillate passes to an accumulator, termed the gas separator. From the top of the tank the gas which is not liquefied passes to the recovery plant while the bottoms or condensed pressure distillate enters the debutanizer. A portion of the condensate is removed from the base of the gas separator and used as reflux to be pumped back over the final bubble tower to strip from the finished overhead the heavier fractions which contain the polymers. The pressure of the final bubble tower is carried at 20 pounds and the overhead temperature maintained at 300°F. The polymers are drawn from the base of the final bubble tower and pumped to the cracking unit to mix with the reduced crude, or led through final coolers and stored for shipment.

FINISHED GASOLINE

The finished product, termed the Lachman gasoline, shows very little difference in boiling range as compared to the pressure distillate entering the zinc chloride system. The pressure distillate vapors condensed for laboratory analysis have an initial boiling point of 92°F. and an end point of 384°F. The recovery is 98 per cent while the Lachman gasoline shows an initial boiling point of 90°F. and an end point of 381°F. The recovery of the Lachman gasoline as shown by the Engler distillation is 98 per cent. The color of the raw pressure distillate sample indicates a light straw while the finished Lachman gasoline is 30+. The octane rating of the pressure distillate is 70, and the Lachman gasoline has the same value.

The product leaving the Lachman gasoline condensers shows a trifle sour in testing with doctor solution, and to counteract this a complete sodium plumbite treating system was installed, designed with the unit. After being debutanized, the gasoline is passed through this unit and to storage as finished gasoline ready for blending. These tanks, three in



Treating tanks for sodium plumbite and vapor recovery unit.

number, are placed in a horizontal position, and are 7 x 28 feet with half-inch shells.

The bottoms from the first tower—the contact column—contain the sludge and spent zinc chloride, and are transferred under operating pressure to the reconditioning system. Two tanks set on high brick foundations receive the zinc chloride as it comes from the contact column. They are set high so as to drain into either of two other tanks near the ground. In the vessels above the zinc chloride supply tanks, the liquid drawn from the contact column, is diluted with water and permitted to settle. The liquid remaining above the sludge is drawn to the supply tanks and the sludge washed a second time, either hot or cold water being used, and permitted to settle again. After the liquid has been drained away, the sludge is pumped to a leaf filter set in a building above the reconditioning tanks and as the cake is pressed, the liquid drains to the tanks below. The cake formed in the filter is pressed and dumped, and contains such a small percentage of zinc chloride that it is economically unprofitable to attempt its recovery.

ACTION OF ZINC CHLORIDE

Quoting Dr. Lachman as to what happens when the pressure distillate is contacted with zinc chloride, he says: "So far as the gasoline itself is concerned, the action of zinc chloride is largely a matter of guess work. Except for the side reactions to be considered in a moment, it can only be described as 'catalytic'. It seems certain that little or nothing happens to the hydrocarbons, saturated or unsaturated. The high ultimate recovery, and the unchanged octane number of the overhead fraction, permit of no other conclusion; and the amount of polymerization is very small. The amount of impurities responsible for gum formation and color instability cannot exceed a fraction of one per cent; in all likelihood they are aldehydes or other oxygen containing substances, on which zinc chloride is well known to have a condensing effect. This theory is supported by the fact that the higher fractions contain small amounts of highly colored, flourescent substances.

"When directly connected to a cracking plant giving fixed gases which contain hydrogen sulfide, some of the zinc chloride reacts to form zinc sulfide according to the reversible equation:

$$ZnCl_2 + H_2S = ZnS + 2HCl$$

The amount is not large, and the reaction obeys the mass law; the greater the proportion of hydrogen sulfide in the gas and the higher the pressure, the more zinc sulfide is formed.

"Another reaction leading to slight zinc losses is hydrolysis, also a reversible reaction:

$$ZnCl_2 + H_2O = Zn(OH)\,Cl + HCl$$

The hydrolysis increases with temperature, and also

Worthington turbine driven pumps delivering water to cooling tower.

with the concentration of the zinc chloride at any constant temperature.

"It is clear from the quantity of zinc chloride consumed per barrel of gasoline treated that no appreciable amount of chlorine can have passed into the gasoline, even if all the chlorine in the zinc chloride had been transferred in that manner. Direct experiments have confirmed the conclusion that chlorine in not present in treated gasoline in measurable quantities. A sample of 2.0 grams was burned in the ordinary sulfur lamp, and the absorption liquid tested for chlorine by the nephelometer. The difference between the amount found and the quantity in the blank test of the reagent employed was too small to be estimated. In further test, 100 cc of gasoline was heated for several hours with 1 gram metallic sodium wire and when taken up in water, the alkaline solution was entirely free from chlorine ion."

As the system designed and installed at McPherson is sufficient in capacity to treat 4000 barrels of pressure distillate in the vapor phase, the time of contact between the vapors from the bubble tower and the zinz chloride in the final contactor was computed after an analysis of the crude to show what was to be removed. The contact tower was built with the dimensions of eight feet in diameter and 55 feet in height to give the average variable. Intimate mixing is of prime importance with this system, so that any amount of pressure distillate vapors up to the capacity can be treated successfully. Variable volumes of vapors do not effect the final result as shown in this plant during a cold wave a short time after the plant was placed in operation. Some of the controls did not function properly due to having been partially frozen. The temperature during this time fluctuated widely and the vapors entered the contact tower in slugs. Experiments were conducted during this period, and the operator of the system purposely threw the system out of balance to determine if fluctuating temperatures and pressures would cause a variable result in the product leaving the final bubble tower. Close check maintained by the laboratory disclosed no variation in the finished product, and when the weather became normal, the product leaving the final condensers was of the same general characteristics as that produced when operated with widely fluctuating temperatures and pressures.

After all the processes of crude debutanizing, skimming, cracking, reforming and treating the pressure distillate in the vapor phase through the routing operations, have been performed the vapors arising from these operations not condensed into liquid, are passed to the recovery plant for further processing. This plant is a combination, in operation, of the pressure distillate stabilizer, final gasoline fractionator and compressors with the usual complement of pumps, condensers and receivers.

GAS PLANT

The gases are picked up from the various points by three Clark 200 horsepower gas engine-driven compressors, running at 200 rpm. The vapors entering are compressed to 65 pounds to condense the higher boiling fractions contained in the gas charge. Residue, or uncondensed fractions pass back to the high pressure cylinders, and are boosted to 265 pounds at the discharge, and at a temperature of 175°F.

The pressure distillate is picked up from the Lachman gas separator and pumped through heat exchangers to the distillate stabilizer, a tower 5 x 55 feet with the bottom temperature maintained at 215°F. Overhead vapors are partially condensed and

the tower trimmed to 102°F. with reflux from the accumulator drum. Bottoms under a temperature of 78°F. are passed directly to the final sweetener for finishing.

Light gasoline produced by the first stage of compression, that produced from the pressure distillate stabilizer overhead, and the product from the crude debutanizer, are pumped to the final gas stabilizer. This tower which is 4 x 80 feet, made from one-inch steel, receives the gas from the high compression cylinders. Gasoline charged to the tower is passed through exchangers and preheaters, entering the bottom section of the tower at 300°F. The product from the overhead is condensed in a combination water and expanded gas cooler, the water section placed above the other. Propanes and the butanes removed from the charge in the column are received in a drum and a part is pumped back to control the top temperature of the column, which is maintained at 132°F. The uncondensed propanes taken from the top of the overhead receiving drum are passed through a control valve which expands them from 265 pounds through the expanded-gas-cooler.

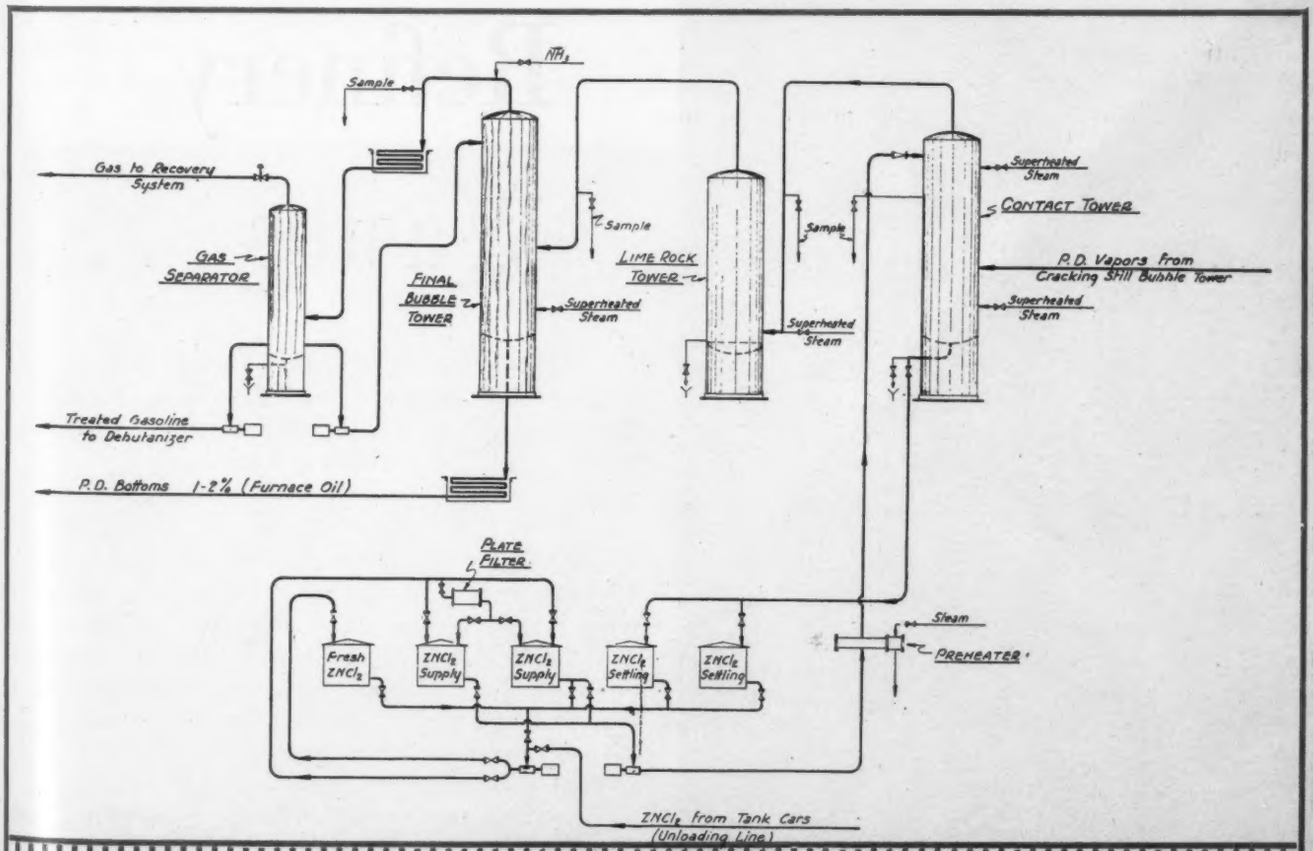
The bottoms from the final gasoline stabilizer are led directly to the "doctor" sweeteners for final treatment before being placed in horizontal storage. These sweeteners, three in number, are 4 x 16 feet, placed horizontal on concrete piers. The first is the sodium plumbite contact receiver, the second caustic wash and the third water wash and settler. The sulfur for processing is placed in a small receiver and the gasoline and doctor are mixed in Duriron contactors.

Steam for plant use is generated in two 500 horsepower Heine water tube boilers, utilizing a Venturi type forced draft stack. The water fed to the boilers is conditioned with a Graver hot process water softener, exhaust steam from the pumps being used to heat the water.

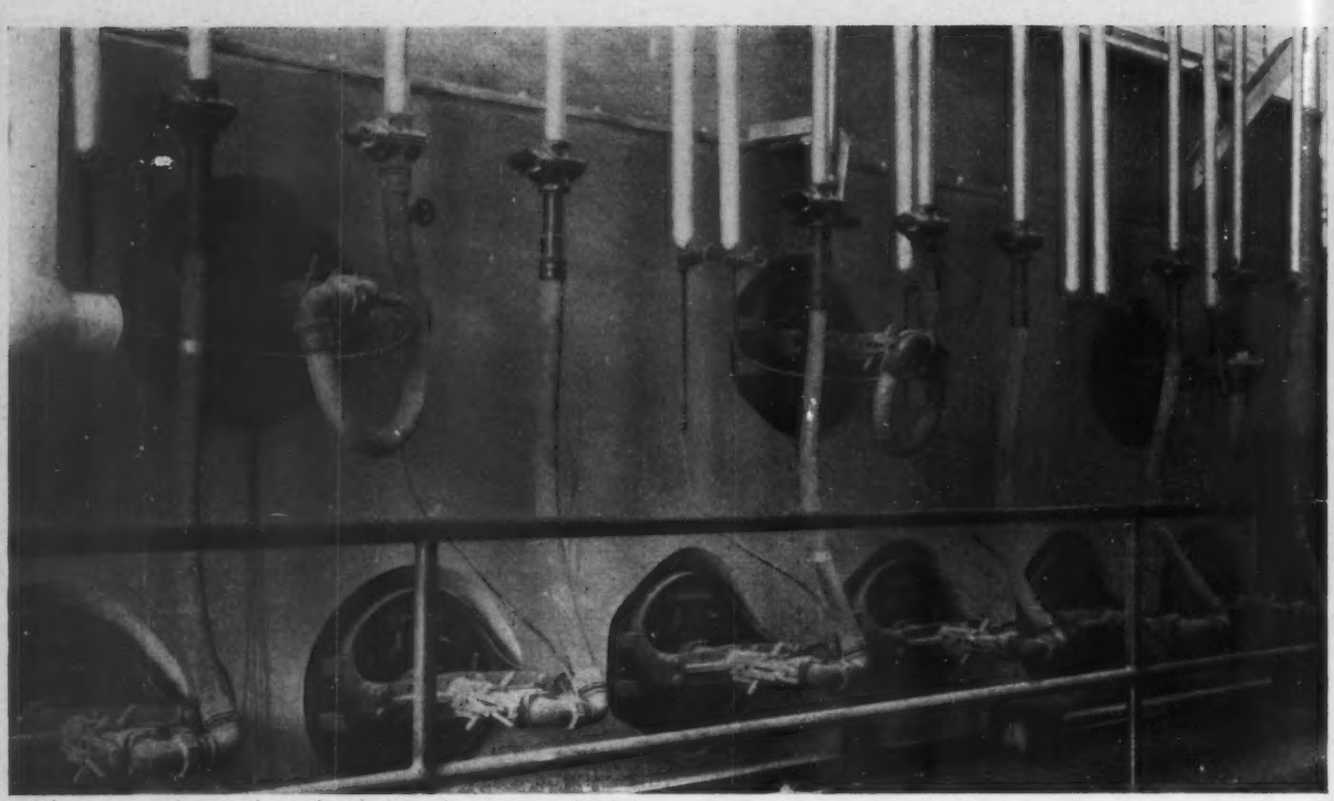
Water is cooled for plant coolers and condensers by a Pritchard tower. Raw water is produced from yard wells with a Layne Western motor driven pump. Solids contained in the water are troublesome and the Graver process reduces them to an average of two grains before being fed to the boilers.

Control instruments in the cracking and reforming and crude debutanizing sections are set on a panel in the control room. These are Brown recording controllers. Those in the gasoline recovery and pressure distillate stabilizing unit are also Brown, while the valves which control the pressures and levels are Foxboro and Fisher type. Goetze Gaskets were used throughout the plant.

All plate work in fabricating the various vessels, towers and accumulator tanks was done by American Tank & Equipment Company, while insulation of the lines, towers and exchangers was furnished and applied by Johns-Manville.



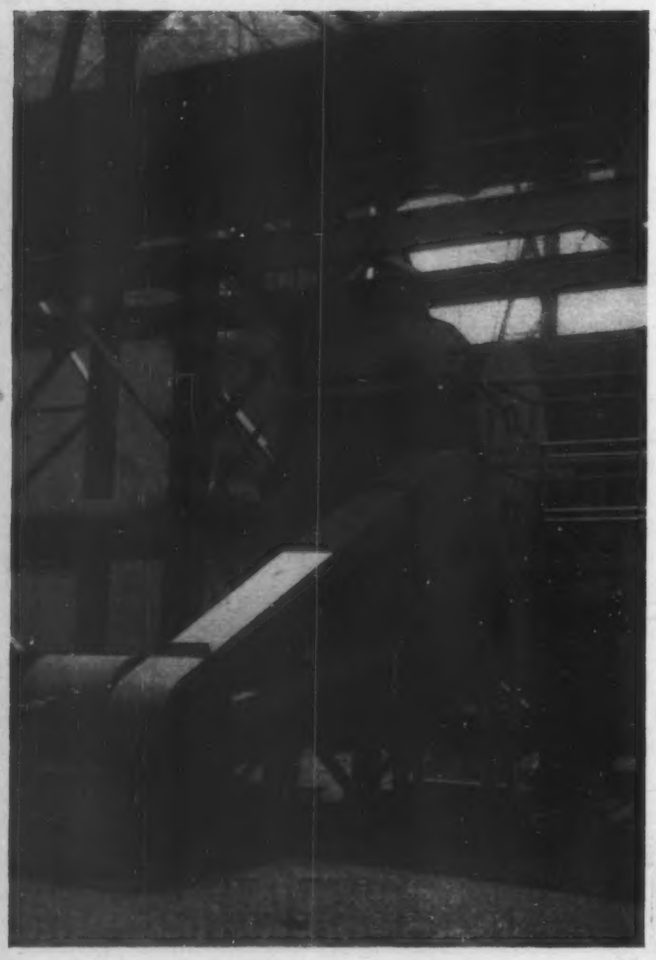
Flow diagram of Lacknan Treater, Globe Oil & Refining Company, McPherson, Kansas



Above—Combination burners in boiler service.

Below—Coke crusher and conveyors.

The Burning of



Refinery Wastes . . .

V. R. CHADBOURNE
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REFINERY wastes are to a certain degree the necessary evils of the petroleum refining industry. While it is the duty of the operating staffs to eliminate them as far as possible, there is a limit from the economic standpoint in their recovery. Consequently, it falls to the lot and is also the duty of the engineering staff to turn as much of this waste as possible back to usefulness in some other form.

Fortunately most refinery wastes are combustible and all refineries require immense quantities of steam.

Boiler units are now designed of such capacities as to allow large heat releases in the furnaces. Also con-

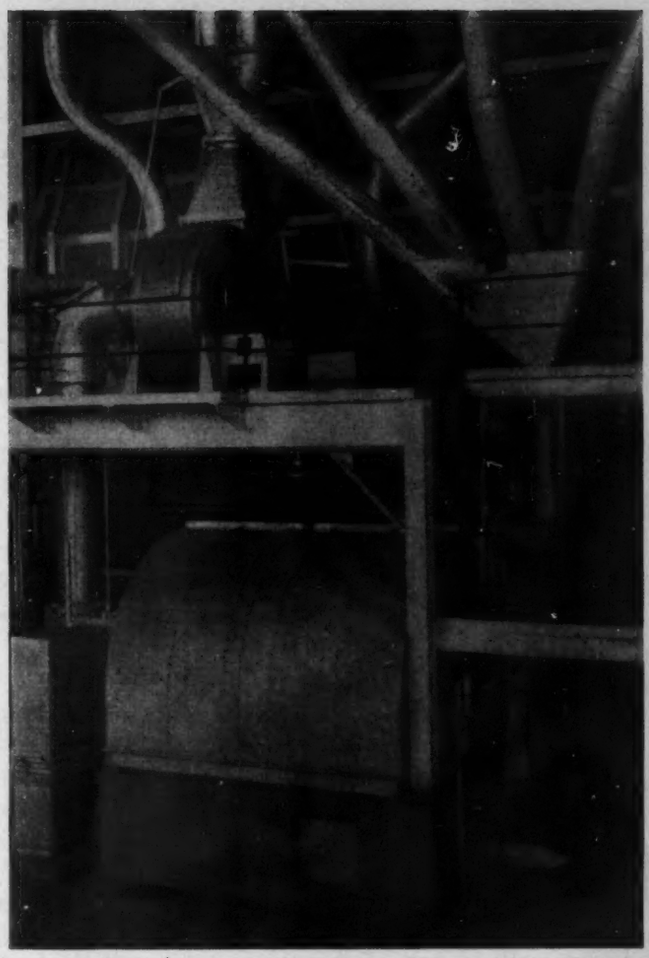
trol of furnace temperatures need not be as close as those of a still furnace.

Thus it has been found that the best disposal of refinery wastes is to burn them under boilers and convert as much as possible of their heat value into steam.

The most common wastes which must be utilized are still gases, acid tars, acid sludges, alkaline sludges, neutralized sludges, wax tailings, heavy residues or pitches and coke, together with a mixture of most of them in a semi-solid state.

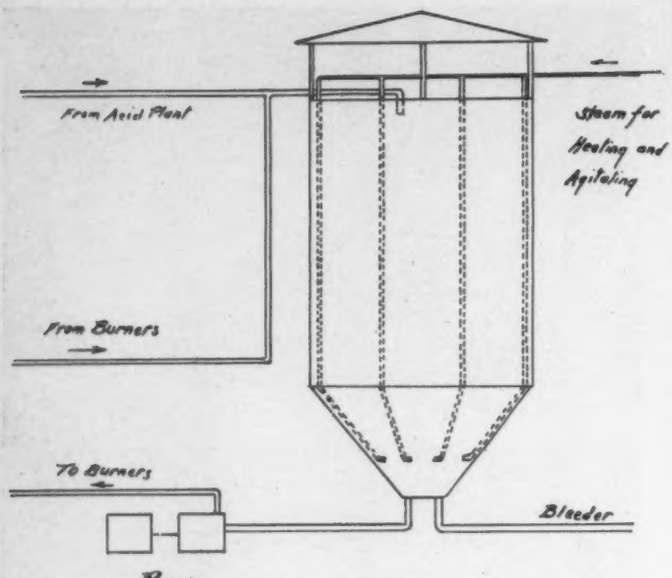
Some of these present no great problem in their disposal in an efficient manner, others are more difficult. All, however, can be burned more or less efficiently with the proper equipment and the proper preparation.

Up-to-date rotary sludge burners are perhaps the best means of efficiently burning mixtures of refuse such as general cleanings of stills and tanks where there are large quantities of solid or semi-solid matter. These burners are also used for burning sludges directly without fluxing or other preparation, although when burning such fuels where the Btu content is low it may be necessary to burn gas or oil in the same furnace to sustain combustion. They are now built up to capacities of several thousand pounds of waste per hour and give practically no trouble with linings or driving mechanism. They are a very satisfactory means of waste disposal where conditions are such that they may be used. However, their use requires a highly special type of design which cannot be readily adapted to conventional boiler plant layouts where it is desired to burn sludges in conjunction with other fuels in the same furnace. They



Above—Installation of coke pulverizing and burning equipment on a Sterling boiler.

Below—Combination burners on a cracking still furnace (oil disconnected).



Service Tank for Sludge Fuels

also have the disadvantage that the space required for their installation in the boiler room is considerable.

In those refineries having only small quantities of this type of semi-solid wastes the use of hand-fired grates under boilers will generally provide means of disposal of it, although not so efficiently.

Nearly all refinery waste fuels except coke can be put in a liquid or gaseous form by heating and by mixing or fluxing with low grade oils or tars when necessary. Burner manufacturers have developed combined burners in which any one of the three forms of fuel, liquid, gaseous or pulverized, may be fired through the same throat opening into the furnace and in which use is made of a common passage for the combustion air. With these burners, liquid fuels may be burned either with mechanical atomization or steam, merely by minor changes.

Combined burners have several advantages over independent burners. Among these are that fewer burners are required, making operation and installation easier; that all burners are identical, thus simplifying air control, wind box and furnace construction; that there are no idle burners to protect as all burners may be kept in operation at all times, and that ignition temperatures can be maintained in the furnace by burning fuels such as oil or gas at the same time with other fuels containing much moisture or with little volatile content.

All these advantages have been of great aid in the development of the possibilities of burning refinery wastes successfully.

Gaseous fuels, of course, present no great difficulties in burning. When burning unstripped gases which have a heat content of sometimes as high or higher than 2000 Btu, it is sometimes difficult to obtain the best appearing furnace condition due to the presence of a large percentage of hydro-carbons and also because there may be considerable quantities of raw distillate in suspension. However, in any modern refinery it is rarely required that such valuable gases be burned. A stripped gas is easily fired, although perhaps not as easily as natural gas. This is due to the fact that the Btu content, and often the pressure, varies greatly, according to the methods of still operation and operation of recovery plants.

FIRING COKE

Petroleum coke, once handled with more or less difficulty on grates or stokers, is now best burned in pulverized form. Coke brought from storage or directly from the stills is first passed through a crusher. From the crusher it may pass to a storage bin or be fed directly to the pulverizing mills from which a mixture of powdered coke and hot air is drawn by the exhauster fans and blown into the furnace through either special coke burners or combination burners. In passing through the crusher the coke is reduced to sizes of approximately 1½ inches in diameter. The amount fed to the mills is determined by a feeder under the control of the operator. The level of fuel in the mill may now be controlled automatically but an experienced operator can tell by the sound of the mills whether his feed setting is correct. The air supplied is from the forced draft fans and is heated either by air preheaters or air-cooled walls. A secondary air supply enters the burner through the wind box.

Trouble is experienced to a certain extent with oily coke which interferes with the proper fineness and the rate of pulverizing. Oily coke has also been the cause of fires in the equipment as heated air is used for sweeping the mills. Coke which has been stored for some time and thus contains much foreign matter sometimes produces a very objectionable slag. This slag adheres to certain tubes in the boilers and attacks the brickwork. This slag action has been found to be particularly severe when coke is burned simultaneously with alkaline fuel.

Unit pulverizers for the individual steam units is now an established method for handling coke. Ball mills have proven to be very successful in pulverizing this form of fuel, although the amount of steel balls required to pulverize coke is of considerable more than that required for coal. This amount is not excessive. One company in the past year has used on an average of .5 pounds of balls per ton of coke pulverized. This company has been experimenting with the use of steel scrap, of which every refinery has large quantities, and finds that it can make use of it as a grinding medium with good success. Its cost of handling coke from the cars, crushing, pulverizing and blowing into the furnace was less than $0.70 per ton. By using scrap as just mentioned, the cost will be lower.

Coke, due to its high carbon content, can be burned in pulverized form with a minimum of excess air (even less with gas) and with high furnace efficiency. It is excellent in forcing a furnace but is a little more difficult to control at light loads. Heat releases higher than

20,000 Btu per cubic foot of furnace volume can easily be obtained with it. It is a good stable fuel and once the furnace is hot other fuels such as oil or gas need not be burned in the same furnace with it as an insurance against its failure to ignite. Best results are obtained when at least 90 per cent will pass a 200 mesh screen. Its ash content is so small as to be a negligible factor in cleaning furnaces.

SLUDGES

The various sludges present individual problems in preparation, handling and burning, yet there are a number of factors common to all which are of great aid in combustion. All the sludges must be kept hot and continually circulated and agitated. Their successful combustion is greatly aided in large furnaces where efficient mixing of the atomized fuels and air can take place without impingment on the surfaces of either metals or brickwork and where good draft control can be had to vary quickly the amounts of excess air necessary for varying mixes. Atomization must be complete, while whether steam or mechanical atomization is used, depends upon several factors.

Lubricating acid sludge appears to be one of the big problems of the combustion men. This sludge is extremely variable in its characteristics, depending not only upon the initial crude stock, but also upon the method of treating that stock, including the amount and type of oil used for fluxing as well as the method of agitating the flux with the sludge. It varies continually and widely in viscosity, gravity and moisture. Its preparation differs in many refineries. No definite rules can be laid down for its treatment. As to whether or not it is properly fluxed or sufficiently agitated only visual observation of experienced operators can determine. Each batch must be constantly agitated by steam jets to prevent solid particles from settling out.

It has been found possible to burn much of such fuel with mechanical atomized burners, although some of it is burned with much better results with steam atomized burners. When mechanical burners are used this sludge burns well at pressures between 190 and 200 pounds per square inch and at temperatures of from 250° F. to 300° F. The temperatures required depend upon the characteristic of the particular batch of oil being burned. To reach these temperatures requires the use of some sort of closed heater as the steam sprays in the open service tanks can only bring the temperature of the sludge to slightly above 200° F. This introduces various troubles in the form of the proper acid resisting metal to be used in them.

Acid sludge containing excessive amounts of acid due to heavy acid treating not only increases the corrosive action of the sludge but at the same time decreases its Btu value. Some companies which burn this sludge without separation have found it worth while when this occurs to make attempts to separate some of this acid.

Acid tars present no great problem except corrosiveness. They are easily handled if kept warm and agitated by open steam jets. For burning in mechanical burners the suitable pressures and temperatures are 150 to 160 pounds per square inch and 165° F. to 175° F. The range in temperatures required with acid tar is not so great as with acid sludge, as this fuel is not normally so variable in consistency. All heating can be done by steam jets in the service tanks. Occasionally acid tars prepared by fluxing sludges with heavy oils after acid separation and washing has taken place, contain an excessive amount of moisture or weak acid, making a fuel or very low Btu content and requiring the burning of an excessive amount of other fuels in conjunction with it.

It is noticeable that at times when batches of acid tars or sludges from different grades of treated oils or crudes are mixed in service tanks some reaction occurs causing a separation of acid or acid water. As this has practically no Btu value, means must be provided for drawing it off from the fuel lines. Usually treaters know from experience between which batches such reactions are likely to occur. Where there is more than one service tank they do not mix such batches and in event there is only one service tank it is allowed to empty before the next batch is introduced.

Alkaline sludges sometimes present a combustion problem in that deposits of sodium sulphate are formed which completely bridge over between the boiler tubes and have a fluxing action on the refractories when burned simultaneously with coke. This is often so serious that the unit must be taken out of service for external cleaning.

The residue from modern stills, such as pitches and heavy gums, together with wax tailings, can be easily disposed of in a rotary sludge burner. These can also be burned in mechanical atomixed burners, provided they are kept at temperatures of 300° F. or over.

"Dubbs Residium" is a fuel with characteristics of alkaline sludge and can be burned much the same although it usually contains a considerable amount of carbon in suspension. Furnace refractories are fluxed by it also.

Due to the unstable quality of most of the sludge fuels it has often been found advisable and desirable to fire gas or oil simultaneously in the same furnace.

On installations where only 60 per cent to 70 per cent of the total load of the furnace is taken care of by the sludge burned it can be burned in modified steam atomized burners with refinery or natural gas acting as the atomizing medium. Tests have proved the use of gas for atomization as practical and a distinct gain over using steam as the heat value of the atomizing agent is made available in the furnace. The sludge particles are thus not only atomized but are intimately mixed with an easily ignitable fuel. The result is complete combustion of the solid material in suspension and the maintenance of a high furnace temperature.

The acid tars and lighter sludges are easily pumped

by ordinary brass liquid end reciprocating steam pumps after they are heated. There is more difficulty with the heavier sludges and some companies prefer to use a screw type pump. Because of their corrosive action, lead lined tanks must be used for receiving and brass lines for transporting acid tar and acid sludge. Alkaline sludges are readily handled and delivered through steel lines and pumps as is fuel oil. It is not possible to store the acid sludges so they must be burned with as little delay as possible. As mentioned, these must be constantly agitated by open steam jets in order to keep them at the proper consistency for pumping and burning.

With all sludges constant flow through the supply piping and re-circulation to the supply tank must be maintained in order to prevent stoppage of lines. When shutting down a line it should be thoroughly blown out with steam and if an acid fuel line is out of service for an extended time it is well to completely charge the line with fuel oil in order to counteract the corrosive effects of the acid fuel as far as possible. Acid tar or acid sludge can be pumped a considerable distance either by use of steam jackets on the line or without them when the line is well insulated, the fuel is hot and when the line is heated by blowing steam through it before the pumping starts. Cone bottom tanks are used for all sludges.

High stacks are a necessary adjunct of boiler houses burning acid fuels. By releasing the gases of combustion high in the air a better diffusion is obtained. This tends to dissipate objectionable odors as well as to prevent any considerable concentration of acid vapors.

ACID RESISTING BURNERS

The use of acid fuels has made necessary an intensive search for metals and alloys which would be acid resisting. It is gratifying to note that the users of these fuels have been fairly successful in obtaining burner tips, barrels and valves with a reasonable length of life. Some of the more common metals used successfully are acid bronze, red brass and supernickel, while numerous acid resisting alloys have been developed.

It is interesting to note that one company looking around for means to help "beat off the depression" has utilized discarded cracking still tubes for an acid tar line. These tubes welded together in 60-foot sections with welded flanges have been in service for some time without giving any trouble and have shown that their life in such service will be of length to warrant the expense of installation.

Those companies who have used acid fuels for steam generation report that apparently no real detrimental effects have occurred either in the furnace or on the heating surfaces of the boilers or economizers. True there has been some corrosive action in certain locations, such as air preheaters. However, if arrangements are made in the design of economizers and air preheaters to keep the exit gas temperatures to at least 250° F. it is felt that the corrosive action will not be excessive. Apparently acid fuels cause little damage to refractories and it seems immaterial whether air-cooled or water walls are used in the furnaces. Most companies have taken the precaution to protect the chimneys serving boilers fired by such fuels with an acid proof lining.

While of course the real purpose of burning refinery wastes is to rid the properties of wastes otherwise hard to dispose of, yet it is essential, especially in this period of economies, to do so with the most perfect combustion possible. It is a very hard matter for the combustion engineer to be at all times certain that he is obtaining the best efficiency. This is due to the constantly changing character of the material being burned. Still gases vary greatly and sludges more so. At times it is possible to obtain high CO_2 while at others it seems impossible to burn the stuff. Drafts must be varied to meet different conditions. However, where the conditions under which the wastes are burned are favorable, such as large furnace volume, sufficient draft and not too large load demand, it is possible by close attention of the operating crews to make very favorable records. Of course all boiler plants are not equipped with CO_2 recorders and automatic controls, but even those that are can not depend wholly upon such devices due to the mixture burned. If the flue gas analysis shows O_2 not exceeding from 2 per cent to 5 per cent without the presence of CO and with a clear stack, then but little fuel is being wasted. With pulverized coke or with still gases there is little excuse for not obtaining high efficiencies while with the lower grade fuels conditions may render it impossible to make a very good showing. Yet the combustion engineer must bear in mind that he is still rendering a service to his company by disposing of this material even though conditions beyond his control seem to make his efforts look poorly.

It is to the credit of the engineering staff that they have accomplished so well the task of not only utilizing the refinery waste but that they have utilized them in such an efficient manner.

Precision Calorimetry . . . *for* Gases

W. F. FULTON

Chief Chemist, United Gas Public Service Company, Houston, Texas

THE present method of determining the heating value of gases in most laboratories is by use of the flow calorimeter. This type instrument is subject to such a large number of corrections, and the accurate control of conditions in order to secure results within 0.5 per cent accuracy, we decided to build a precision calorimeter for gas so that we could calibrate our flow and recording calorimeters.

In order to calibrate a calorimeter with hydrogen, we have to determine the accuracy of the analysis, if the calorimeter results are compared with a combustion analysis we have the possibility of the determination of the inerts being in error by 0.5 per cent or more, in fractional analysis we still have the error in the determination of the inerts, such as oxygen and nitrogen.

A combustion analysis will check within 0.5 to 1.0 per cent of the determined B.t.u. if the gas has a high methane content, and as the percentage of ethane and higher hydrocarbons increase in the gas the error in a calculated analysis will increase.

For precision work the calibration of calorimeters by gas analysis is not accurate enough due to the inaccuracies of the gas analysis itself.

Use of hydrogen depends on the purity of the hydrogen, if the analysis is in error by 0.2 to 0.5 per cent, or 0.6 to 1.6 B.t.u. The error in burning 1000 B.t.u. gas is three times as large or from two to five B.t.u. However, hydrogen is the most commonly used gas for calibrating recording calorimeters.

We have found that flow calorimeters are accurate enough for routine determinations if properly checked and operated, however, the discrepancy between calorimeters located in different laboratories was greater than it was for a single instrument. These discrepancies are caused by personal error, weather conditions, room and water conditions, methods of sampling, accuracy of calibration of all parts of the instrument before making the determination and finally corrections applied to the results. The accuracy can be improved very much if all the above conditions are checked carefully and uniform procedure determined for all locations. In this manner the error can be lowered to approximately three to five B.t.u. per cubic foot.

In order to calibrate and check flow calorimeters and recording calorimeters we have constructed a precision calorimeter similar to Bureau of Standards Calorimeter used in the determination of the Heat of Formation of Water (Bulletin No. 259 by Frederick D. Rossini, Jan. 1931), also used in determination of the Heat of Combustion of Methane and Carbon Monoxide (Research Paper No. 260 by Rossini, Jan. 1931). We have also followed suggestions and precautions of Walter P. White in Modern Calorimeter, which are essential for precision work.

METHOD: GENERAL

The method consisted of burning a known volume of gas with oxygen in a pyrex glass bomb placed in a known quantity of water in a calorimeter can surrounded by a shield and outer jacket of water of predetermined temperature. The temperature rise of the calorimeter water was measured by a resistance thermometer, and the water in the calorimeter proper and the jacket was stirred by a constant speed motor.

The glass bomb or reaction chamber was surrounded by the calibrating heater which was used to heat the mass of water (n) degrees while measuring the voltage and current applied, and in this manner the amount of heat necessary to raise the mass of water in the calorimeter 1°C. was determined in international joules. The voltage and current being measured by a sensitive potentiometric system, and the current was timed by an electric clock with electric contact to operate solenoid switch through a relay, for accurate determination of the time of heating in seconds.

APPARATUS

The assembly of apparatus consisted of the gas measuring bottle which was made of a Pyrex glass bulb with top and bottom necks graduated. This bulb was placed in a glass water jacket and supported on iron rods. This measuring bulb was similar to a standard 0.1 cubic foot bottle, except for the water jacket used in order to maintain constant temperature while measuring the sample. The capacity was 2200 cc of gas. The gas passed from the top of the measuring bulb which was attached to a purifying tube filled with Ascarite to remove the CO_2 and water vapor, then through a flow meter and capillary coil to insure that the gas was at room temperature before entering the calorimeter reaction vessel.

The oxygen was passed through a similar train, except the oxygen was fed direct from a drum of com-

mercial oxygen with a regulator, and the accurately calibrated flow meter used to determine the amount passed through the calorimeter during the determination.

REACTION VESSEL AND ITS OPERATION

The reaction vessel in which the gas and oxygen were burned consisted of a Pyrex bulb (eight inches long—1¼ inches diameter), in the bottom of which passed the capillary tube extending into the bulb (2½ inches), with a platinum tip (one half-inch). The oxygen entered the bottom and side of the bulb. The reaction products of the combustion passed out the top through a (one half-inch) pyrex tube which was coiled around the combustion bulb, and had a length of approximately nine feet, then passed up and out of the calorimeter.

The entering tubes for the gas and oxygen contained platinum wires leading down to the top of the burner so that an electric spark could be used to ignite the gas and oxygen.

The vessel was operated by flushing out the vessel with oxygen and also the gas inlet tube. When the combustion was started the spark was passed across the tip and with the oxygen flowing at the proper rate the gas was started, and as soon as ignited the spark was stopped (two to three seconds being the time required to ignite the gas).

DETERMINATION OF WATER FORMED AND EVAPORATION LOSS

The outlet tube of the reaction vessel was attached to a U-tube containing Dehydrite in which the water vapors contained in the excess oxygen and the carbon dioxide were absorbed and determined, this amount of water being used to correct for vaporization energy. Then after the combustion was completed and the after-period over, the vessel was removed and again attached to the U-tube and all the water of condensation in the vessel was removed by heating the vessel with hot air and passing dry gas through the vessel and U-tube, this amount of water being that formed during the combustion of the gas and remaining in the vessel, so half this amount was used to correct for water formed, or added to original amount of water in the calorimeter.

THE CALORIMETER AND MEASURING INSTRUMENTS

The calorimeter consisted of an inner calorimeter can holding 5000 cc of water up to within one cm. of the top when the reaction vessel was in place, this can was surrounded by a shield of thin nickel plated copper (approximately one cm. from can). The outer jacket was three inches larger than the inner jacket wall or a three-inch column of water surrounded the inner chamber on all sides and the bottom. The cover for the calorimeter can fitted inside and extended into the water, this cover also was used to support the stirrer. The jacket stirrer was attached to the outer jacket and independent of the cover.

The jacket water was maintained at a constant temperature by means of an electric heater made of nichrome wire (28 gauge) coiled in a small pyrex glass tube bent in U shape. The heater was connected in series with a lamp bank and the current controlled manually. The temperature was measured with a certified Centigrade thermometer graduated in 0.1°C., and as the jacket contained approximately eight gallons of water and the room temperature change was slow, there

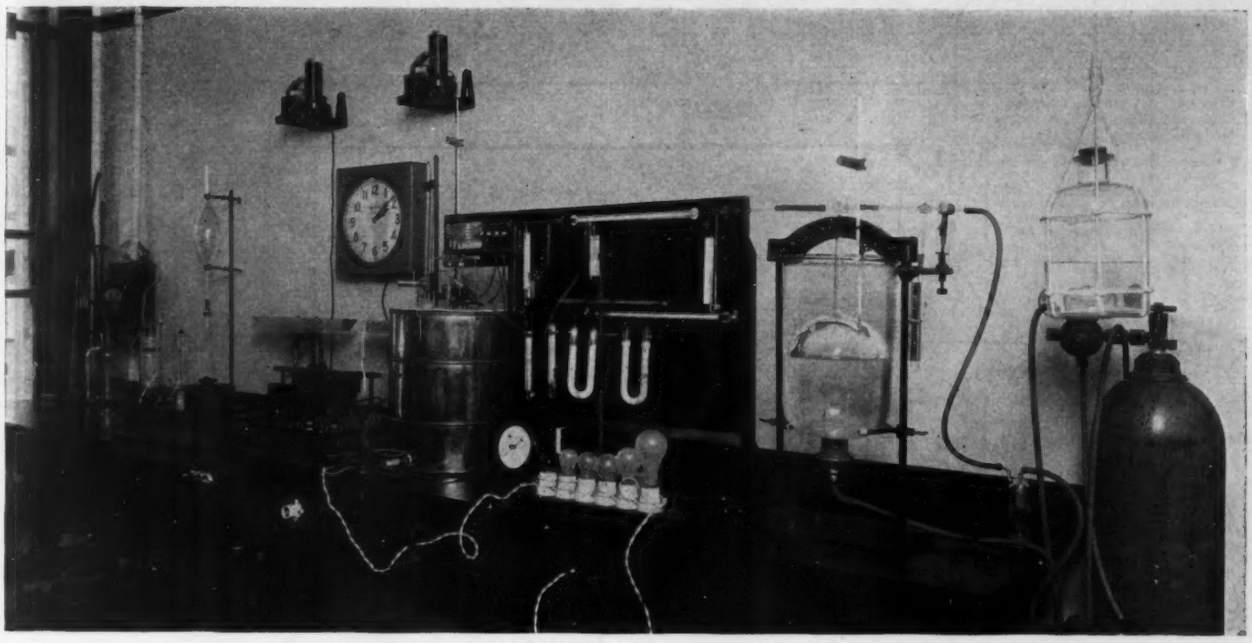
Combustion Experiments with Hydrogen

	ΔR	k	u	K	U	Δ R Corr.	Δ T Corr.	Ave. Temp.
Hydrone Hydrogen	.11597	.0011733	.0000873	.001009	.001746	.118215	1.133368	29.09
Cyl. Hydrogen	.11478	.0013377	.0000489	.001168	.000978	.112634	1.126515	29.08
Cyl. Hydrogen	.11554	.0013145	.0000492	.001132	.000984	.113725	1.134806	27.14
Cyl. Hydrogen	.11582	.0012273	.0000551	.001081	.001102	.113637	1.137100	27.65
Cyl. Hydrogen	.11588	.0012690	.0000440	.001102	.000880	.113898	1.139193	26.13

	Mass H_2O (G)	½ Mass H_2O Formed	Electrical Equivalent	Press. Reaction M. M. Hg.	Total Energy	Gas Energy	Vap. Energy	Spark Energy
Hydrone Hydrogen	4983.56	.7948	21,417.68	756.3	24,274.11	—11.27	97.56	— 9.00
Cyl. Hydrogen	4982.82	.7770	21,414.56	753.1	24,123.83	— 6.38	90.97	—10.80
Cyl. Hydrogen	4986.54	.7192	21,434.69	755.6	24,324.21	— 2.28	105.61	—10.80
Cyl. Hydrogen	4985.92	.7270	21,430.84	755.0	24,369.01	— 6.37	105.61	— 9.90
Cyl. Hydrogen	4986.42	.8289	21,437.14	756.1	24,421.04	— 5.73	139.75	— 9.00

	Reaction Energy	Vol. Gas Cu. Ft.	Q pt.	Corr. 60° F.	Corr. 30″ Hg.	Q at 60° F. & 30″ Hg. Joules	B. t. u. Cu. Ft.
Hydrone Hydrogen	24,351.40	.072427	336,218.1	681.18	—34.16	336,865.1	319.32
Cyl. Hydrogen	24,197.62	.072730	332,702.6	680.52	—53.4	333,329.7	315.97
Cyl. Hydrogen	24,416.74	.073292	333,143.4	582.81	—38.4	333,687.8	316.31
Cyl. Hydrogen	24,458.35	.073472	332,894.2	608.43	—42.0	333,460.6	316.09
Cyl. Hydrogen	24,546.06	.073677	333,156.4	531.96	—35.4	333,653.0	316.28
					Average for 4 cylinder samples		316.16

The four samples of hydrogen from the cylinders checked within ± .20 B. t. u. of the average. (Purity 98.99%)
The sample of hydrone hydrogen which was 99.97 percent pure checked with Rossinis' results for the Heat of Formation of Water; 319.40 B. t. u. per cubic foot at 60°F. and 30 inch Hg. saturated with water. Our results 319.32 B. t. u. per cubic foot or a difference of .08 B. t. u.
All gas volumes are corrected to 60°F. and 30 inch Hg. saturated with water vapor.



Precision Gas Calorimeter in laboratory of United Gas Public Service Company at Houston, Texas. Above is a photograph of the installation and, below, a reproduction of the blue print by which it was built.

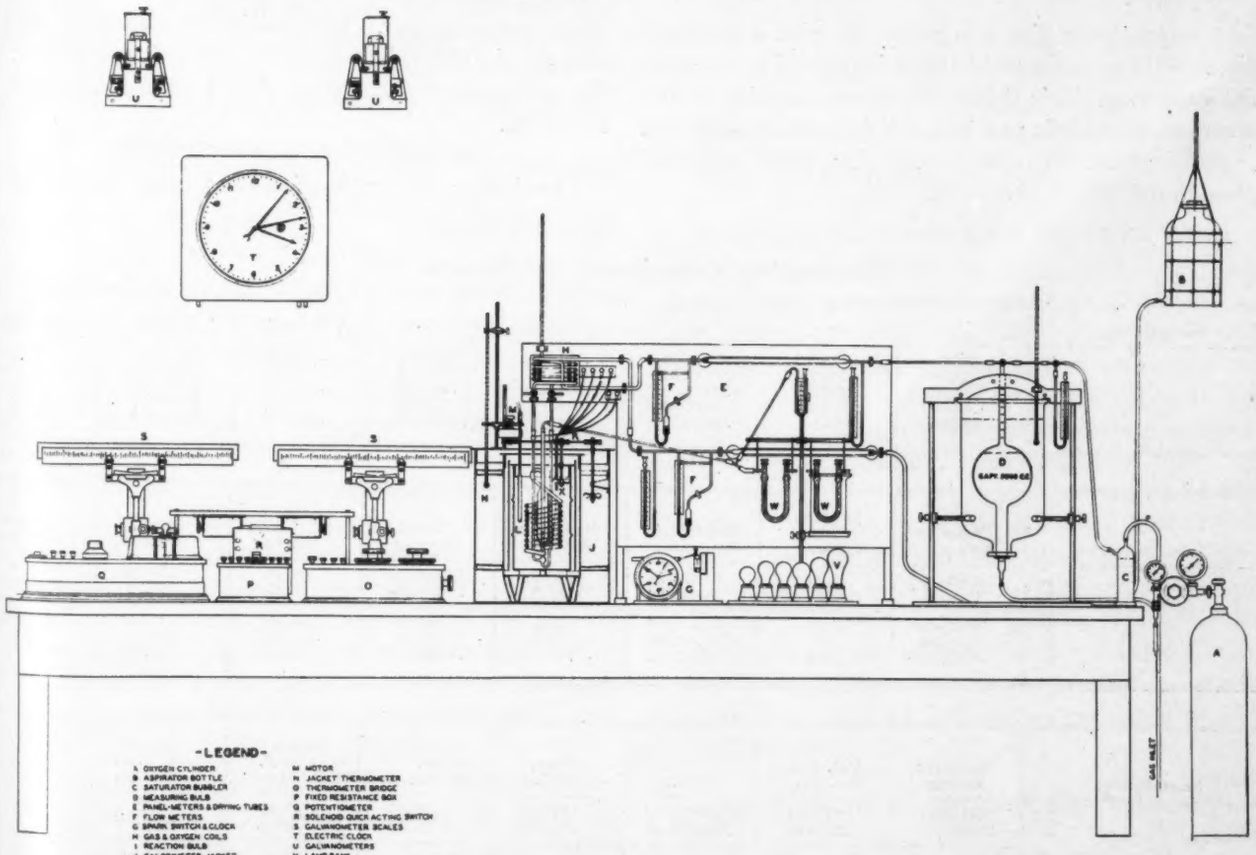


FIGURE 1

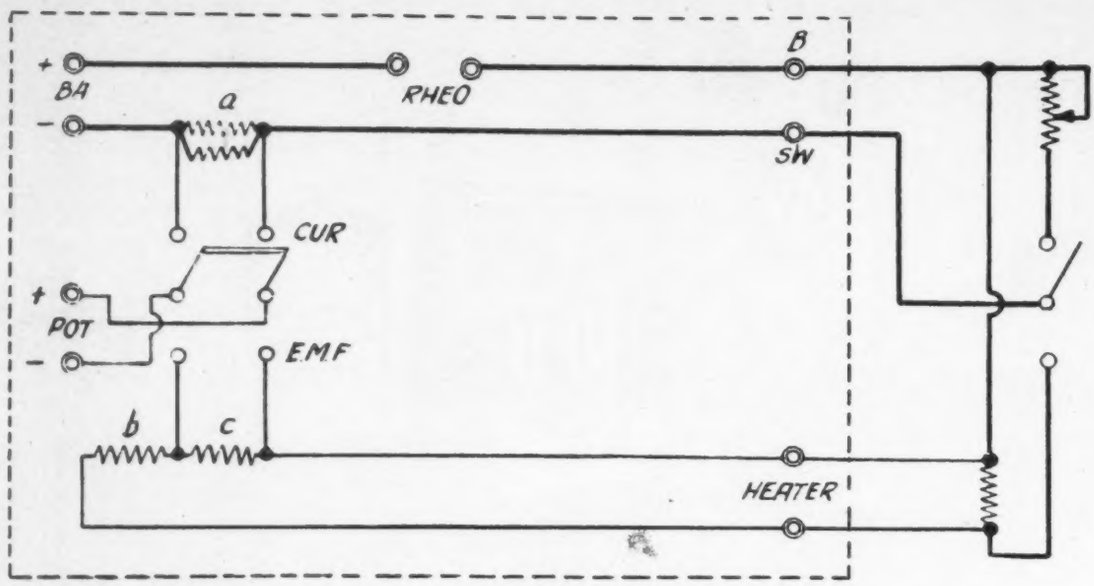


FIGURE 2
Wiring Diagram

was no difficulty in maintaining a constant temperature in the jacket.

The temperature rise was measured with a platinum resistance thermometer which was immersed to the same point each time. This thermometer was certified by the Bureau of Standards and had the following constants: $R_o = 25.5$ Ohms. Increase from 0°C. to 100°C. = 9.927 International Ohms. $\delta = 1.50$.

The resistance of the thermometer was read on a Mueller thermometer bridge attached to a high sensitivity galvanometer. The sensitivity was such that a change of .0001 Ohms caused a deflection of 4 mm. on the galvanometer scale, so that 1 mm. was equal to .00025°C.

ELECTRIC ENERGY SYSTEM

The heater for calibration was made according to

Combustion Experiments on Natural Gas

Sample No.	Δ R	k	u	K	U	Δ R Corr.	Δ T Corr.	Ave. Temp.
1	.35708	.0014276	—.0000303	.0040794	—.000606	.353606	3.540724	29.90
2	.35644	.0014308	—.0000223	.004473	—.000446	.352413	3.528765	29.89
3	.35346	.001395	+.0000654	.004050	+.001307	.348103	3.485366	29.66
4	.35338	.001480	+.0000266	.004272	+.000532	.348576	3.489996	29.56
5	.35367	.001440	+.0000359	.004180	+.000718	.348772	3.492048	29.65

Sample No.	Mass H_2O (G)	½ Mass Water Formed	Electrical Equivalent	Press. Reaction M.M. Hg.	Total Energy	Gas Energy	Vap. Energy	Spark Energy
1	4985.01	1.53	21,424.78	749.2	75,859.23	38.44	306.34	—9.00
2	4982.63	1.53	21,414.86	747.6	75,568.00	15.50	331.70	—8.10
3	4983.93	1.50	21,472.17	758.8	74,838.39	36.52	324.38	—9.00
4	4983.99	1.50	21,472.54	758.8	74,939.08	—11.75	280.24	—9.90
5	4985.12	1.50	21,477.14	760.1	74,999.22	—17.09	311.46	—9.00

Sample No.	Reaction Energy	Vol. Gas Cu. Ft.	Q pt.	Corr. 60°F.	Corr. 30″ Hg.	Joules Q at 60°F. & 30″ Hg.	B. t. u. Cu. Ft.	
1	76,195.01	.073684	1,034.070.00	1593.37	—102.66	1,035,560.7	981.63	
2	75,568.00	.073412	1,033,991.40	1592.59	—115.49	1,035,468.5	981.54	
Average							981.59	
3	75,117.25	.0728854	1,030,620.90	1571.19	— 25.66	1,032,166.4	978.41	
4	75,197.67	.072936	1,031,007.40	1555.92	— 25.66	1,032,537.7	978.76	
5	75,284.59	.073064	1,030,391.90	1570.08	— 15.24	1,031,946.7	978.20	
Average							978.44	

Note: Due to change in reaction bulb the electrical equivalent of the calorimeter was 21,532.78 joules per 1°C. rise for the last three samples of gas.

Bureau of Standards instructions (page 12, Research Paper No. 259), that is, by drawing a thin copper tube over a silk covered constantan wire, 36 gauge B.S., which had previously been given a thin coating of Bakelite. (Complete heater made by Leeds & Northrup).

The leads to the resistance coils were No. 24 gauge B.S. enamel covered wire, and the potentiometer leads were No. 28 gauge B.S. enamel covered wire. The potentiometer leads were attached to the heater leads at a point half way between the top of the calorimeter and the water in the calorimeter, the leads were inclosed in an eighth-inch copper tube and soldered at the bottom and sealed at the top with cement. The copper tube extended above the top of the water in the calorimeter, and the leads passed out the top of the calorimeter.

The electrical energy was measured by measuring the potential drop across the heater, and by measuring the potential drop across a standard resistance placed in the circuit (2-2 Ohms in parallel).

The potential drop was measured with a type K potentiometer and galvanometer.

The current was derived from 16-6 volt batteries connected in series, making a 96 volt battery. An external resistance was connected to the circuit by the quick throw V type solenoid operated switch, which was connected to the electric clock for throwing the current into the heater and off to the external stabilizer, which was the same resistance as the heater (69 Ohms).

The other two fixed resistances were 100 Ohms and 9900 Ohms. In this manner the current flowing was: $\frac{1}{1}\left(1-\frac{69}{10{,}000}\right)$ x potential drop across the two —2 ohms fixed resistances in the circuit. The potential drop across the heater was $\frac{100+9900}{100}$ or 100 times the potential reading for the drop across the heater.

These readings were taken each minute during the calibration, and the potentiometer setting was checked against the standard cell before and after taking the readings, and also two or three times during the calibration period.

The time in seconds the current was flowing was determined by the 12-inch dial clock which had an electric contact on the 12 o'clock point, which the second hand contacted at each revolution, and by throwing a secondary switch in a relay circuit the current was thrown from the external stabilizer to the calorimeter heater by a quick acting V type solenoid switch. In the same manner at the end of 15 minutes (900 seconds) the switch was thrown back to the stabilizer.

The current from the 96 volt battery after remaining on the stabilizer for the 20-minute period was switched to the calorimeter heater and the current was steady varying in the fifth place, the voltage reading varied slightly in the fifth place, after conversion to actual voltage this was equivalent to the third place.

Calibration Experiments

Exp. No.	Δ R	k	u	K	U
1	.31220	.001493	—.0000557	.0044104	—.001114
2	.30874	.001473	—.0000476	.0043001	—.000952
3	.30627	.001414	—.0000210	.0040970	—.000422
4	.30744	.001434	—.0000777	.0041670	—.001555
5	.30409	.001402	—.0000684	.0040300	—.001368
6	.30443	.001426	—.0000447	.0041050	—.000894
7	.30410	.001431	—.0000475	.0041150	—.000950
8	.30473	.001452	—.0000135	.0041860	—.000270

Exp. No.	ΔR Corr.	Factor	Δt Corr.	Ave Temp.
1	.3089036	9.9975	3.08826	24.67
2	.3053920	9.9975	3.05315	24.67
3	.3025950	9.9974	3.02517	24.67
4	.3048280	9.9974	3.04748	24.67
5	.3014280	9.9974	3.01349	24.67
6	.3012190	9.9974	3.01141	24.67
7	.3009350	9.9974	3.00856	24.67
8	.3008140	9.9974	3.00736	24.67

Exp. No.	Amps Current	Volts	Time	Energy	Water Grams
1	1.030936	71.40250	900	66,250.30	4,989.24
2	1.025280	71.01207	900	65,526.56	4,989.90
3	1.020475	70.66850	900	64,903.88	4,991.07
4	1.024019	70.92447	900	65,365.24	4,991.68
5	1.018535	70.52850	900	64,652.18	4,992.32
6	1.018296	70.52885	900	64,637.15	4,990.86
7	1.017706	70.49753	900	64,571.17	4,990.65
8	1.017066	70.44730	900	64,484.64	4,989.24

Exp. No.	Equivalent Joules	Cor. to 25°C.	Cor. to 5000GM H_2O	Electrical Equivalent per 1°C.	Deviation from Mean
1	21,452.28	—.82	44.94	21,496.40	3.24
2	21,461.91	—.82	42.17	21,503.26	10.07
3	21,454.61	—.82	37.28	21,491.06	— 2.13
4	21,448.86	—.82	34.74	21,482.73	—10.46
5	21,454.28	—.82	32.06	21,485.52	— 7.67
6	21,464.15	—.82	36.16	21,499.49	6.30
7	21,462.43	—.82	39.04	21,500.65	7.44
8	21,442.25	—.82	44.94	21,486.37	— 6.82
			Average	21,493.19	± 6.76

% Error .0315%
Error per cu. ft. ±.315 B.t.u.

CONSTANTS, UNITS AND FACTORS USED

The factor 1.0004 was used for converting international joules into absolute joules.

In order to correct for the varying amount of water in the calorimeter the heat capacity of water was taken at 4.175 joules per gram at 25°C. and 4.173 at 30°C. To correct the heat capacity of water to a common average temperature the coefficient was taken as—.00050 joules per gram per degree per degree at 25°C. The ΔCp at 25°C. for oxygen was taken at 29.2 joules per mole per degree, and ΔCp at 25°C. for reaction $CH_4 + 2O_2 = CO_2 + 2H_2O$ was taken as — 93 joules per degree, that is the heat evolved decreases 93 joules per mole per degree increase in temperature. In correcting the vaporization energy the heat of vaporization of water was taken as 2439 joules per gram at 25°C. and 2428 at 30°C.

One gram calorie at 15°C. = 4.185 joules or $\frac{4.185}{1.0004}$ international joules.

For converting moles to cubic feet of gas; B.t.u. per moles × 1.19734 = B.t.u. per cubic foot. Molecular

volume of gases was taken at 23.6957 liters at 60° F. and 760 mm. 1 B.t.u. = 1,054.9 international joules. Pressure correction was taken at —6.7 joules per mm. per mole or —8.02 mm. per cubic foot for gas. The spark energy was found to be 3.60 joules per second.

The water was measured into the calorimeter with a 2000 cc. certified flask and a 1000 cc. certified flask, then the volume was converted into grams at corresponding temperature at which it was measured by Bureau of Standards weight volume tables. The measuring flasks were further calibrated with a special 1000 cc. calibrating pipette with Bureau of Standards report.

CALIBRATION EXPERIMENTS

The calibration experiments were conducted at 25°C., the water in the calorimeter was brought to 23°C. and the jacket at 27°C. When the water was at 23°C. the fore period was started and readings taken every minute for 20 minutes, at the twentieth minute the current was switched from the stabilizer to the calorimeter heater, and the temperaure readings, voltage and current readings taken every minute, after 15 minutes or on the thirty-fifth minute the current was switched back to the stabilizer and temperature readings continued to the sixtieth minute. The readings at 0-20-40-60th minute periods were read with accuracy to the fifth place in ohms on the bridge and galvanometer scale. During the 60 minutes the jacket was held at 27°C.

The method of determination of the corrected temperature rise was as follows:

$$u + \left(R_{J(0,20)} - \frac{R_0 + R_{20}}{2} \right) k = \frac{R_{20} - R_0}{20}$$

$$u + \left(R_{J(40,60)} - \frac{R_{40} + R_{60}}{2} \right) k = \frac{R_{60} - R_{40}}{20}$$

These equations were solved for u and k, then $U = 20u$, and K is found by determining the time in minutes at which .63 of the rise had occurred, and this times $R \times k = K$.

The following results show the degree of accuracy on different B.t.u. gases:

	655.53	829.95	994.27	1,023.49
	655.15	830.50	994.41	1,023.05
Ave	655.34 ± .19	830.23 ± .28	994.34 ± .07	1,023.27 ± .22

CONCLUSION

That a calorimeter of the type described in this paper is satisfactory for the accurate determination of the calorific value of gases.

Comparison of Precision Calorimeter and Flow Calorimeter

Gas No.	Precision Calorimeter	Flow Calorimeter	Difference
1	1,021.11	1,021.0	— .11
2	981.79	986.0	+4.21
3	979.65	980	+ .35
4	984.81	986	+1.19
5	984.33	980	—4.43
6	996.82	993	—3.82
7	1,015.61	1,021	+5.39
8	1,003.51	1,004	+ .49
9	1,074.95	1,075	+ .05
10	1,069.58	1,071	+1.42

The above tables show that the flow calorimeter may be used to determine the B.t.u. of gas with an accuracy of ± 5 B. t. u., if all conditions are controlled and checked.

If the meter is not calibrated before each test the results may vary from 8 to 10 B.t.u. In the operation of a flow calorimeter it is very important that the proper rate of both the gas and water be determined for the type of gas being tested.

Comparison of Precision Calorimeter and Recording Calorimeter

Sample No.	Precision	Recording	Difference
Hydrogen	319.30	319.5	+ .20
1	488.27	488.0	— .27
2	655.59	656.0	+ .40
3	830.28	830.0	— .28
4	1,016.00	1,016.0	.00
5	1,290.97	1,290.0	— .97
	Average Difference		± .40

An accuracy of ± .25 B.t.u. can be secured by the proper care and operation of instruments used in connection with a precision calorimeter.

In order to secure accurate results, caution must be taken in order to have the right amount of oxygen for complete combustion and not too large in excess, otherwise the results will be low due to the formation of ozone and the oxides of nitrogen. We have not experienced any difficulty in burning various types of heat content gases in this type calorimeter. We have burned gases made from mixtures of natural gas and nitrogen with a range from 450 to 1450 B.t.u.

The two most important factors are the accurate measurement of the gas volume and the temperature rise.

ACKNOWLEDGEMENT

Acknowledgement is due to J. P. Sloan for the glass blowing and construction of the calorimeter, and to H. T. Griffin, Jr., and J. C. Allen for the calibrations and experimental results.

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The Refining of *Vapor-Phase Cracked* Gasoline

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FROM a short review of the chemistry of cracked distillates it is indicated that their stabilities depend on the distribution and type of olefines present. Fractionations of cracked distillate show this to be the case and it is suggested that it might be feasible to segregate the most unstable fractions, sweeten or desulphurize them separately and stabilize them by a suitable addition of inhibitor, finally blending the stabilized material with the refined and more natural stable residue.

Methods of treatment of cracked distillates are dealt with briefly and details are given of a continuous counter current method of acid treatment together with the losses involved.

An account is given of the method employed for the evaluation of inhibitors and of the results of testing 60 compounds of possible value. The most effective materials were found to be catechol, hydroquinone, pyrogallol and monobenzyl-*p*-aminophenol. Most of the other materials were found to be less efficient than these, and a few of equal activity caused the development of color either on addition to the fuel or after oxidation in the bomb.

Finally, a description is given of attempts to study the stabilities of inhibited and uninhibited motor fuels by means of an oxygen bomb method, and by standardized storage at 100°F. and at normal atmospheric temperature. As far as can be ascertained, the stabilities shown by the bomb are of similar degree and order as those given by standardized storage at 100°F. This paper was read before the World Petroleum Conference, London, England, July 19-25, 1933.

FROM a general historical consideration of this subject, it is interesting to note that two of the main reasons for the early rejection of vapor-phase cracking processes in favor of liquid-phase methods were, firstly, the difficulty of satisfactorily refining the product, and secondly, even when this was possible, to carry out the treatment without very substantial losses. A review of recent progress in the "art of cracking," however, shows that liquid phase processes are now either being replaced by cracking in the vapor-phase or by composite methods involving both phases. This change has only been made possible by a much improved knowledge not only of the most suitable methods of refining but also of the chemical nature of the material and its reactions with the refining media. The difficulties encountered during the refining of cracked distillates may be many and varied; apart from the main treatment with the selected reagent, trouble may occur due to emulsion formation in the neutralization stage or to the development of acidity on re-running. Again, the stability of the finished gasoline with regard to gum formation and color deterioration may be insufficient, while even odor has hitherto been a fruitful cause of complaint.

THE CHEMISTRY OF CRACKED DISTILLATES

In an attempt to place the refining of cracked distillates on a systematic basis, various workers have determined which types of compounds or fractions were chiefly responsible for those disabilities which refining is intended to remove. One of the earliest contributions of this nature was that of Smith and Cooke,[1] who showed that gummy deposits are caused by oxidation and have no direct relation to unsaturation as determined by solubility in sulphuric acid. Cassar[2] in the same connection has shown that olefine peroxides catalyze the formation of gum in unstable gasolines, that diolefines do not catalyze gum formation if they are free from peroxides, and that the gum content of gasoline fractions bears no direct relation to either boiling point or sulphur content. According to Flood, Hladky and Edgar,[3] straight chain olefines having a double bond at the end of the chain are more stable than those having the bond elsewhere, and with olefines of equal concentration and similar structure those of low molecular weight are the least stable. The presence of a double bond in a cyclic or benzene ring causes compounds of this type to be less stable than the simple olefines, and

TABLE I

Fraction	Boiling Point, °C.	Gum Content, mg./ 100 ml.	Potential Gum Content, mg./ 100 ml.	Sulphur Content, %.	Specific Gravity
1	18–30	—	—	0.08	0.669
2	30–40	4	93	0.11	0.678
3	40–60	4	124	0.08	0.689
4	60–70	7	164	0.05	0.699
5	70–80	10	222	0.01	0.712
6	80–90	16	220	0.04	0.736
7	90–100	19	237	0.04	0.736
8	100–110	91	278	0.145	0.761
9	110–120	61	286	0.14	0.762
10	120–130	60	241	0.13	0.771
11	130–140	59	216	0.23	0.779
12	140–150	21	140	0.16	0.779
13	150–160	21	87	0.19	0.784
14	160–170	7	23	0.16	0.793
15	170–180	7	10	0.15	0.797

(*Note.*—Gum contents were determined according to the air-jet method described in *J. Inst. Petr. Techn.*, 1930, **16**, 684. Potential gum contents were estimated by heating 50 ml. of the sample in a Mahler bomb with oxygen at 10 lbs. per sq. in. and at 100° C. for 20 minutes and finally determining the gum content of the treated sample.)

a double bond adjacent to the ring involves high instability. Diolefines as a class are much less stable than monolefines, but the position of the double bond is important in determining the stability. Conjugated double bonds introduce extreme instability, while a compound containing widely separated double bonds is almost as stable as an average olefine. Cyclic diolefines containing conjugated double bonds seem somewhat less stable than the comparable aliphatic diolefines. Relatively little work dealing with the sulphur compounds present in cracked gasoline has been carried out, but McKittrick[4] has found that they are members of the thiophene series and also isolated some for identification. Even less is known about the color present in cracked gasolines, but it has been stated[5] that the few colored compounds that are known contain conjugated unsaturated groups, as in the compounds of the fulvenes series which range from a yellow to an orange color. In general, the depth of color is proportional to the molecular weight.

THE STABILITY OF CRACKED DISTILLATES

From the foregoing it is obvious that the stability of cracked distillates will depend on the distribution and type of the olefines present. Payne and Lowry,[6] in an examination of 10 per cent fractions of a highly cracked material, found that the proportion of unsaturated and paraffin hydrocarbons decreased as the boiling point increased and that there was a corresponding increase in the percentage of naphthenic and aromatic hydrocarbons. It has also been pointed out[7] that certain fractions contain much more gum than others and that it is possible to separate these cuts and treat them individually if required. Martin[8] has shown that with a certain vapor-phase cracked distillate, gum is obtained from the fraction boiling between 63° and 146° C. with larger amounts in fractions boiling between the limits 74-79° C., 102-107° C., 124-129° C., and it is considered that gum formation is due directly or indirectly to specific compounds which are thought to be conjugated diolefines. Of interest also in this connection are the details of a distillation of material obtained by the vapor-phase cracking of Persian fuel oil, the results of which were as shown in Table 1.

The most striking feature of the distillation was the apparent natural subdivision of the fractions into a group of colorless materials of low specific gravity, sulphur content and gum content, boiling below 100° C., and a heavier group which had quite the opposite characteristics in these respects. It was obvious, however, that the lighter fractions were markedly less stable than the material boiling above 100° C. *Nevertheless, the possibility suggested itself that each of the two groups might best be refined by different methods and subsequently blended.*

THE REFINING OF CRACKED DISTILLATES

The main functions of refining are to reduce the gum content of the cracked material to a negligible amount, to make the finished product substantially water-white and odorless and to provide a marketable material which will not increase in gum content or acquire color during a reasonable period of storage. Apart from the application of refining agents, distillation itself if carried out in a suitable manner will result in a diminution of the gum content and an increase in stability. The effect of heat treatment on various unsaturated hydrocarbons has been studied extensively, and Payne and Lowry[6] have shown that by heating under pressure, the percentage of unsaturated hydrocarbons is decreased and naphthenes increased. There is also evidence[7] to show that polymerization takes place during a slow distillation so that polymerized bodies may be separated by reason of their higher boiling points.

Of the many and varied methods of refining which have been tried, treatment with sulphuric acid is definitely the most universally used. For the refining of vapor-phase cracked distillates, however, solid adsorbents such as fuller's earth, active clay and silica gel are frequently used, and Gerstenberger[9] claims that clay treatment yields gasoline with 14 per cent higher anti-knock rating than is obtained by acid treatment. Apart from these two methods, many others have been tried or suggested. Lachman,[10] for example, has shown the value of solutions of certain salts and deals specifically with a hot concentrated solution of zinc chloride as a means of treatment. Phosphorus pentoxide, aluminum chloride, caustic soda fused with metallic oxides, phosphoric acid and activated charcoal are only a few of the reagents which have been tried for specific pur-

poses, and hydrogenation is known to be a successful, if expensive, method of treatment.

ACID TREATMENT

In the literature in particular, acid treatment has commanded more attention than any other method; it is relatively easy to apply and in most cases does not require very specialized apparatus. Sulphuric acid acts as a strong polymerizing agent and transforms olefines into gummy substances non-volatile in steam, the extent of the transformation depending largely on the strength and quantity of the acid.

Trusty,[13] in examining the effects of various factors in the refining of cracked distillates, has shown that the amount of acid formed at rerun stills may be reduced by a low temperature of treatment, short periods of agitation and settling time before neutralization and an increase in the amount of steam used during distillation. Water washes and strength of caustic wash do not affect acid formation. Color is improved by short periods of agitating and settling, by long periods of settling prior to distillation and by an increase in open steam used for distillation. Color is not affected by temperature of treatment or by water washing or by strength of caustic wash. The sulphur content is reduced by long acid agitation and settling time before neutralization, but only slightly by water washing before neutralization.

Acid treatment may be carried out batchwise or continuously with weak or strong solutions, but for vapor-phase cracked distillates, a continuous treatment or a succession of small treatments with progressively stronger acid is desirable.

CONTINUOUS COUNTER-CURRENT TREATMENT WITH ACID

Continuous counter-current treatment[11] offers distinct advantages over the batch method, especially with regard to ease of control and savings in time, chemicals and labor, and has been utilized with success for the treatment of vapor-phase cracked distillates.

In this particular case, the plant consists of a series of interconnected pairs of vessels of which one is an agitator fitted with a specially designed, eccentrically positioned paddle, and the other a separator. The oil and reagent enter the plant as opposite ends and leave at the ends remote from those at which they entered, the oil thus being alternately agitated with and separated from reagent, which becomes progressively stronger from pair to pair. This is effected without the use of pumps by taking advantage of the flows of reagent and oil induced by the difference in the density of the three liquids—oil, reagent and emulsion of oil and reagent.

The addition of the acid results in the formation of a tar which is usually three times the volume of the added acid and therefore contains about 30 per cent of free acid, except in the case of the oil entry vessel, where a lower content is registered due to dilution with traces of water contained in the material to be treated. The ratio of oil to tar in the plant is maintained at 4:1, and hence it should be realized that treatment is really effected by means of the acid tar, the purpose of the addition of acid actually being to maintain the requisite amount of free acid in the tar. Refining is therefore brought about by dilute acid in which the diluent is the polymerization product of the reaction. A similar degree of treatment, however, cannot be brought about by the use of acid diluted to 30 per cent strength with water. In most cases a satisfactory product is obtained by maintaining the acid tar to be 20 per cent by volume of the total liquids in the plant with an addition of 96 per cent sulphuric acid equivalent to 0.2 to 0.4 per cent of the throughput of cracked distillates.

Slight traces of acid tar left in the acid treated distillate are frequently responsible for the formation of quite stable emulsions in the neutralization stages, so that it is advantageous to follow acid tar treatment with a wash with water or spent soda solution before final neutralization with caustic soda solution (1 of 5 per cent).

After neutralization, the treated distillate is dark red in color and contains large quantities of gum which must be removed by distillation. Using batch distillation from shell stills, this presents little difficulty, but where continuous distillation is used in conjunction with heat exchangers as the source of heat, the heating must be effected by means of a circulating heater, otherwise the exchanger will be quickly clogged with a soft granular type of gum. In either case, owing to the evolution of sulphur dioxide during distillation, the distillate must be neutralized, if not during condensation, then certainly at the worm end. Sulphur dioxide results from the decomposition of residual traces of dialkyl-esters of sulphuric acid formed during treatment and has a very detrimental effect on the color and gum content of the distillate.[12]

The method of treatment outlined above, followed by suitable rerunning, results in a substantially colorless and gum stable material which on being subjected to the potential gum test (outlined above) does not give a result higher than 5 mg. per 100 ml., the conditions of test being equivalent to at least six months' storage in steel barrels at normal English atmospheric temperature.

The treatment losses by this continuous counter-current method usually amount to between 3 and 3.5 per cent of the raw feed and may be divided into a loss due to tar formation of approximately 1 per cent and one of 2 to 2.5 per cent due to volatilization of the light ends. The latter percentage when added to volatility losses incurred during rerunning will bring

the total loss up to approximately 4 to 5 per cent. The actual yield of refined material (treated and redistilled) will depend very largely on the distillation range of the raw feed. When the feed has a relatively heavy "tail," then obviously the yield of finished gasoline of approximately 195° C. end-point will be smaller than when the distillation range is shorter. The yield will thus vary between extremes of 65 and 80 per cent.

It is conceivable that a considerable proportion of the 4 to 5 per cent of loss due to volatilization might be saved if the colorless fraction boiling to 100° C. were segregated, sweetened and stabilized separately, leaving the heavier and highly colored fraction to be refined by methods similar to that already described. The light cut (to 100° C.) is of very high anti-knock value and any savings of this material would be of considerable importance. It is, however, very unstable and would necessitate a suitable addition of gum inhibitor after sweetening to confer sufficient stability to allow of its storage without deterioration.

THE USE AND APPLICATION OF INHIBITORS

In order to avoid gum formation in cracked gasolines, or its fractions, it is necessary to prevent the condensation, polymerization or oxidation of the unsaturated bodies brought about by the presence or formation of peroxides. A stable product may be obtained by suitable chemical treatment, but this always results in a loss of volume and anti-knock effectiveness. Provided that present gum content, color, sulphur content and odor are satisfactory, it is possible by the addition of small amounts of inhibitors to delay the formation of gum and color, and if this can be accomplished for a sufficiently long period, the necessity for the removal of the gum-forming substances with the attendant losses is obviated. It is to be noted, however, that gum inhibitors do not prevent gum formation, but only create a delay period before gum formation commences. The application and use of inhibitors have commanded a considerable amount of attention and details of investigations have been published extensively. Summaries of this work[14] and [15] have already appeared in the literature, so that it will be unnecessary to review the recent publication here.

THE ESTIMATION OF STABILITY

In the following, therefore, it is proposed to summarize the work carried out by the author on the evaluation of inhibitors, using the apparatus designed for the estimation of general stability and described in a separate paper under another section of this Congress.

In brief, the apparatus consists of a steel bomb of 1000 ml. capacity coated on the inside with vitreous enamel and fitted with a screw-on cap carrying an oxygen filling-valve and safety explosion-disc. For the operation of the test, 400 ml. of the sample is sealed in the bomb together with oxygen at a pressure of 10 pounds per square inch, and the whole heated at 100° C. for varying periods of time. On completion of the heating, the bomb is quickly cooled, the sample removed and examined with regard to present gum content (air-jet method),[16] and, if required, color and anti-knock value. Curves relating time in the bomb with gum formation, increase in color or loss of anti-knock value form a very convenient method for evaluating and comparing the general stabilities of samples.

THE EVALUATION OF INHIBITORS

The first part of the work consisted in the evaluation of the relative effects of what at the time were the best known inhibitors, namely, cresylic acid, hydroquinone and catechol. For this purpose, various additions of the inhibitors were made to a highly unstable sample of vapor-phase cracked gasoline and the mixtures heated in the bomb at 100° C. with oxygen (10 pounds per square inch) for 30 minutes, gum contents being determined at the end of each treatment, with the following results (also shown on Figure 1):

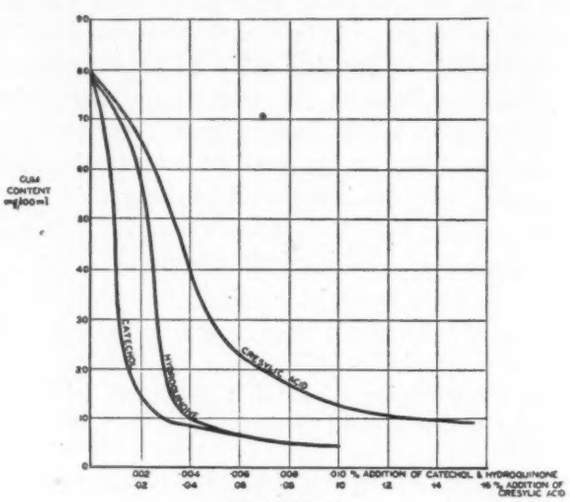

FIGURE 1

Comparison of the inhibiting actions of Catechol, Hydroquinone and Cresylic acid

TABLE II

Cresylic Acid		Hydroquinone		Catechol	
% by wt.	Gum Content after 30 mins. in Bomb, mg./100 ml.	% by wt.	Gum Content after 30 mins. in Bomb, mg./100 ml.	% by wt.	Gum Content after 30 mins. in Bomb, mg./100 ml.
0.00	80	0.000	80	0.000	80
0.03	58	0.001	70	0.0005	74
0.05	28	0.002	63	0.001	49
0.075	20	0.004	10	0.0025	12
0.10	11	0.006	7	0.005	8
0.15	11	0.008	6	0.0075	7
—	—	0.01	3	0.01	4

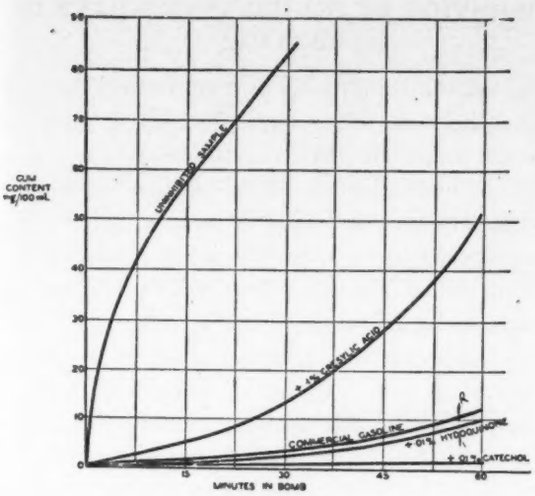

FIGURE 2

Comparison of the stabilities of inhibited gasolines

From the above, the amounts of each inhibitor required to stabilize the sample were deduced to be 0.1 per cent in the case of cresylic acid and 0.01 per cent for both hydroquinone and catechol. These amounts were added to separate portions of the original sample and the mixtures subjected to oxidation in the bomb for varying periods of time. The gum content figures obtained as a result of this experiment are given below, together with those of a commercial grade of motor spirit:

TABLE III

Time in Bomb, mins.	Original Sample, mg./ 100 ml.	Sample +0.1% Cresylic Acid, mg./ 100 ml.	Sample +0.01% Hydroquinone, mg./ 100 ml.	Sample +0.01% Catechol. mg./ 100 ml.	Commercial Spirit, mg./ 100 ml.
15	58	8	1	1	2
30	80	11	2	2	3
45	104	27	5	2	6
60	130	52	10	2	12

By plotting stability curves (Figure 2) it was seen that two of the inhibitor samples were equal in stability to the commercial grade of fuel, and that, broadly speaking, hydroquinone and catechol were 10 times as efficient as cresylic acid.

*Private communication from Dr. S. F. Birch.

With regard to the latter, a comparison of the isomers of cresol with phenol (Table IV) shows that *o*- and *p*-cresol are more active than *m*-cresol, while the latter is comparable in its action with phenol.

TABLE IV

MATERIAL	GUM CONTENTS		
	After 20 mins. in the Bomb, mg./ 100 ml.	After 60 mins. in the Bomb, mg./ 100 ml./	After 120 mins. in the Bomb, mg./ 100 ml.
Unstable Gasoline.....	135	296	357
Do. + 0.1% *o*-cresol.....	48	165	288
Do. +0.1% *p*-cresol.....	32	154	286
Do. +0.1% *m*-cresol.....	88	234	302
Do. +0.1% phenol.....	94	192	294

In view of the excellent results obtained by the use of the dihydric phenols—catechol and hydroquinone—it was considered desirable to investigate the polyhydric phenols as a class still further, and accordingly resorcinol, pyrogallol, phloroglucinol and orcinol were tried, with the results shown in Table V. Compared with hydroquinone and catechol, only pyrogallol proved to be effective, giving results somewhat superior to these two materials. To account for the apparent inactivity of the remainder, it has been suggested* that their symmetrical structure makes them incapable of quinone formation and hence they are less likely to be effective inhibitors than those which can easily be transformed into quinones.

Following this preliminary work, and having developed a suitable technique, a search was made for materials having similar stabilizing effects to those of pyrogallol, catechol and hydroquinone. Sixty compounds of possible value have been tested by the method used for the evaluation of the polyhydric phenols and their efficiencies compared with those of catechol and cresol. Apart from pyrogallol, monobenzyl-*p*-aminophenol and hydroquinone, none of the samples was the equal of catechol in general suitability. *p*-benzylidineaminophenol and *p*-benzyl-aminophenol were also of the same inhibiting power as catechol, but suffered the disability of causing color development on addition to the gasoline and after oxidation in the bomb. Somewhat less effective than catechol were a condensation product of

TABLE V

Catechol		Orcinol		Hydroquinone		Resorcinol		Pyrogallol		Phloroglucinol	
Amount added to Unstable Spirit, %.	Gum Content after 30 mins. in Bomb, mg./ 100 ml.	Amount added to Unstable Spirit, %.	Gum Content after 30 mins. in Bomb, mg./ 100 ml.	Amount added to Unstable Spirit, %.	Gum Content after 30 mins. in Bomb, mg./ 100 ml.	Amount added to Unstable Spirit, %.	Gum Content after 30 mins. in Bomb, mg./ 100 ml.	Amount added to Unstable Spirit, %.	Gum Content after 30 mins. in Bomb, mg./ 100 ml.	Amount added to Unstable Spirit, %.	Gum Content after 30 mins. in Bomb, mg./ 100 ml.
0.00	70	0.00	70	0.00	70	0.00	70	0.00	70	0.00	70
0.0025	39	0.001	70	0.0025	34	0.0025	80	0.001	67	0.001	72
0.005	17	0.01	71	0.005	15	0.005	83	0.002	12	0.005	71
0.01	6	0.1	100	0.01	4	0.01	83	0.005	6	0.01	74
—	—	—	—	—	—	0.1	97	0.01	3	0.1	105
—	—	—	—	—	—	—	—	0.015	3	—	—

hydroquinone, piperdine and formaldehyde, ∝-naphthol β-hydroxyphenyl-βnaphthylamine, and di-aniline hydroquinone, the last three, however, giving an undesirable color on their addition to the gasoline. *O*- and *p*-tert. buthylphenol and di-butylamine ∝-naphthol were similar to cresylic acid in effectiveness, but the last of these suffered from color development. Thymol and three xylenols (1:2:4, 1:2:6, and 1:3:2) all gave results comparable with cresylic acid. The first of these, however, imparted its very characteristic odor to the gasoline, while 1:2:6 and 1:3:2 xylenols were both responsible for the development of a bright yellow color after oxidation. Of the remainder of the samples, some had only slight gum-inhibiting properties, some noticeably hydrocarbons and alcohols, were entirely inactive, while in a few cases the action was to accelerate gum formation.

Finally, it is of interest to note that certain types of petroleum contain a number of phenolic compounds capable of gum inhibition. Japanese petroleum[17] contains appreciable amounts of the three cresols and 1:3:4-*m*-xylenol together with smaller amounts of 1:2:3-*o*-xylenol and di- and tri-ethylphenol. A similar series of these natural inhibitors has been isolated from the soda extract obtained during the refining of Persian cracked gasoline, together with small amounts of phenol and 1:2:4 and 1:3:2-xylenol.

THE INTRODUCTION OF INHIBITORS INTO CRACKED SPIRIT

Cresylic acid is easily soluble in cracked gasoline, but inhibitors such as catechol and hydroquinone are only soluble in benzene at normal temperatures to the extent of approximately 1 per cent and 0.3 per cent, respectively, while hydroquinone appears to be less soluble than catechol in cracked gasoline. In fact, one of the chief disadvantages of hydroquinone is the ease with which it crystallizes from petroleum spirit. The introduction of such materials is hence a matter of some importance, as it is undesirable, both on the score of cost and for reasons specific to the solvents themselves, to have to use such solvents as benzene, alcohol or acetone. Most of the inhibitors examined are easily soluble in alcohol or acetone, but in many cases they are precipitated on being introduced into the spirit.

A convenient method of overcoming the solubility difficulty is to dissolve the inhibitor in cresol (*e.g.* 10 per cent solution) and to add the mixture direct to the spirit, as this gives at once a satisfactory solution. The stabilizing effect of the mixture is the proportional arithmetic mean of the components. An important point to be noticed in the practical application of the polyhydric phenols in particular, is that, owing to their ease of solution in water, they should only be added to materials which are not subsequently exposed to contact with considerable volumes of water.

BEHAVIOR OF INHIBITED GASOLINE IN STORAGE

Although the bomb test was a convenient method for assessing the value of inhibitors in delaying gum formation in the particular cracked gasoline used, it is at present unknown whether the same assessment would hold good for inhibited materials in storage, particularly if the gasolines were of other origin or produced by different methods (*e.g.* benzoles, coal spirits or liquid-phase cracked gasolines.)

Insufficient information is yet available to permit the correlation of gum stability as judged by bomb tests with actual data from medium or large-scale storage over a sufficiently long period, but the results given graphically in Figures 3-5 show that the use of the bomb

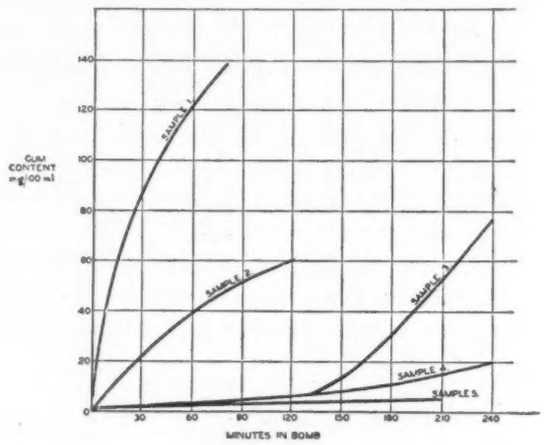

FIGURE 3
Comparison of stabilities of inhibited and uninhibited samples by means of the bomb

brings out differences in stability induced by the introduction of an inhibitor which are not in every case apparent with laboratory storage. The diagrams are largely self-explanatory, but further, it should be stated that laboratory storage consisted of placing eight litres of the sample in a two-gallon can which had been previously cleaned by boiling out with successive amounts of distilled water, rinsing with acetone and drying. The aperture of the can was fitted with a cork carrying a short length of glass capillary tubing and a thermometer. The capillary tubing was intended to allow of breathing effects in the can and the capillary itself was chosen so as to be commensurate with a breather pipe in a large-scale storage tank.

One set of samples was stored at 100° F., while the other was allowed to acquire normal laboratory temperature (35-68° F.) Sample 1 was an unrefined vapor-phase cracked spirit, sample 2 a partially refined material of the same type. Sample 3 was the same as sample 1, but inhibited with 0.01 per cent of catechol; sample 4 was a commercial grade of gasoline, and sample 5 was the same as sample 2, but inhibited with 0.005 per cent of catechol.

With regard to the action of the inhibitor on gum

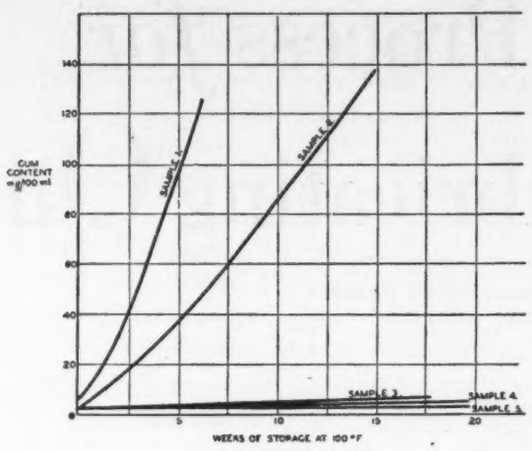

FIGURE 4

Comparison of stabilities of inhibited and uninhibited samples by means of storage at 100° F.

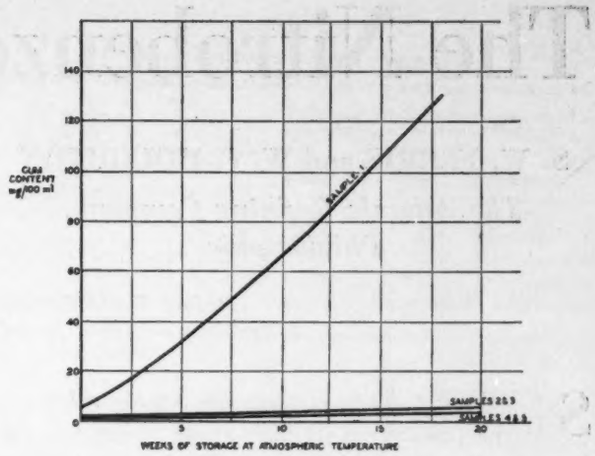

FIGURE 5

Comparison of stabilities of inhibited and uninhibited samples by means of storage at atmospheric temperature

content, it will be seen on comparing the bomb test curves (Figure 3) for samples 1 and 3, that the inhibitor has conferred a definite stability which has lasted for a period of about 120 minutes in the bomb. After this period, the rates of deterioration of the inhibited and uninhibited samples are approximately the same. A comparison of the bomb test curves for samples 2 and 5 (Figure 3) indicates a similar phenomenon, but the inhibited sample has not yet reached the time limit of its stability. Up to a period of 120 minutes in the bomb, it will be seen that the stabilities of the inhibited samples are the same as that of the commercial gasoline, which incidentally is known to be stable under all conditions of storage. The latter observation also holds good in the case of storage at 100° F. (Figure 4), and this type of storage also shows samples 1 and 2 to be unstable. Storage at atmospheric temperature for 21 weeks (Figure 5) tells us practically nothing about the effectiveness of the inhibitor and only shows sample 1 to be unstable.

CONCLUSION

Although the liquid-phase cracked gasolines do not usually present any great difficulties with regard to treatment, the refining of vapor-phase cracked material is not always either simple or effective, the most disadvantageous feature being the relatively heavy losses of material and anti-knock value. To take only a few instances, acid treatment is perhaps the most straightforward method, but in some cases, it compares unfavorably, as regards yields, with clay treatment. Refining with zinc chloride shows a certain amount of promise, especially as its polymerizing and condensing action on unsaturated bodies is less violent than that of sulphuric acid. The process, however, is fairly new and has not yet had sufficient time to prove itself fully on the large scale.

The use of inhibitors gives even greater promise, and there are indications that their employment will go far to solve some of the difficulties of refining, particularly those relating to treatment and volatility losses. It may be that separate inhibitors may have to be used to prevent the deteriorations due to gum and color formation, but nevertheless their cost will almost certainly be far less than the value of the losses. Their successful use, however, depends to a very great extent on the availability of a satisfactory potential gum test in order that their reaction may be gauged with a reasonable degree of certainty. The development of such a "yard-stick" and its correlation with storage conditions is therefore of paramount importance, and the uncertainty which exists with regard to the various potential gum tests reflects itself directly on the present-day development of refining methods.

The author is indebted to the Anglo-Persian Oil Company for permission to publish the results of experimental work presented in this paper.

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The Nitrobenzene Process *for* Lubricating Oils*

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SOLVENT extraction processes are aimed primarily at the production of high-grade motor oils. Apart from the fundamental property of lubrication, those oils are considered most desirable which have the least change of viscosity over the temperature range of a cold to a fully heated engine; the least tendency to form sludge, *i.e.* to oxidize; the lowest evaporation loss; and the least tendency to form carbon. The "paraffinic" in comparison with "naphthenic" lubricants exhibit all these properties to the greater degree with one exception. "Naphthenic" oils because of their lower boiling range for a given viscosity have the advantage in respect to carbon formation; this quality may be obtained in paraffinic oils by taking overhead fractions of sufficiently narrow boiling range, of course at the expense of yield from crudes. There is no strict line of demarcation between paraffinic and naphthenic oils as there is none between the crudes from which they are derived. All oils and all crudes contain both the desirable and undesirable compounds indicated by those terms but in varying percentages. Of motor oils obtained by conventional refining processes, those from Pennsylvania crude are outstanding but are sharply limited in volume; this is especially true if stress is laid on minimum carbon deposition, since this, requiring sharply fractionated overheads, would further reduce the supply.

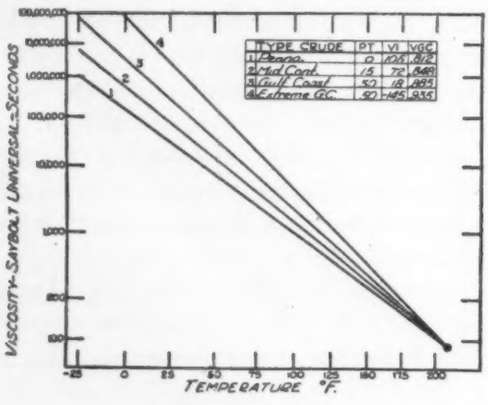

FIGURE 1
Range of Viscosity-Temperature Slopes for Natural Oils

Separation by selective solvents of the most paraffinic compounds from the viscous fractions of the entire gamut of crudes from the non-asphaltic Pennsylvania to the highly asphaltic type promises not only an adequate supply, but a control and degree of quality hitherto practically unattainable, except by expensive synthesis.

For the purpose of this paper, that oil which has the higher A.P.I. gravity for a given viscosity is assumed to be the more paraffinic, and this relation is expressed numerically by the Hill and Coats,[1] "Viscosity Gravity Constant"; the lower the value of this constant the greater the paraffinicity.

Dean and Davis'[2] "viscosity index" is quite generally used for the same purpose, and reflects the viscosity-temperature relationship.

A value which reflects this latter relationship in terms directly applying to engine performance, dubbed "parvis temperature," is defined as the degree Fahrenheit at which a given oil has the same viscosity at 0° F. as that of a standard paraffinic oil whose viscosity at 210° F. is that of the given oil.

The correspondence between all these values is illustrated in the table of Figure 1; the curves of the figure show the variation in viscosity over the normal temperature range of four heavy motor oils all 90 sec. Saybolt Universal viscosity at 210° F., obtained from four typical crudes. The increasingly high torque required to start a motor at 0° F. as the paraffinicity decreases is apparent.

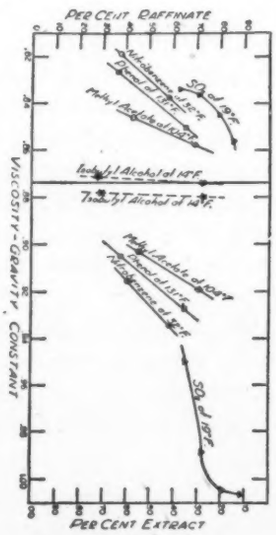

FIGURE 2
Comparison of Selective Solvents:
(a) Efficiency of Separation

*U. S. Patent No. 1,788,569. Other patents pending.

The criteria of a good selective solvent are:

(1) Extreme paraffinicity of the raffinate.
(2) Low volume required per volume of raffinate.
(3) Ease of separation of the layers.
(4) Ease of recovery.
(5) Chemical inertness.
(6) Variety of charge stock to which it may be applied.

Figures 2 and 3 compare the action of five solvents on an oil of properties given below. Sulphur dioxide, nitrobenzene, phenol, methyl acetate and isobutyl alcohol were chosen from a large group as giving typical comparisons between solvents having widely different characteristics.

The properties of the stock employed follow:

Saybolt viscosity at 100° F., seconds	612
Saybolt viscosity at 210° F., seconds	57
Gravity, deg. A.P.I.	20.6
Viscosity-gravity constant (V.G.C.)	0.874
Viscosity index (V.I.)	19
"Parvis" temperature (P.T.), ° F.	29

Each result given in these two charts was obtained by a single treatment of fresh oil with the individual solvents.

The vertical line in Figure 2 represents the stock, V.G.C. 0.874, so that the raffinates fall to its left and the extracts to its right; it will be noted that the two ordinate scales are reversed, so that the complementary fractions from each treatment lie on horizontal lines, and the distance between them indicates the selectivity of the solvent.

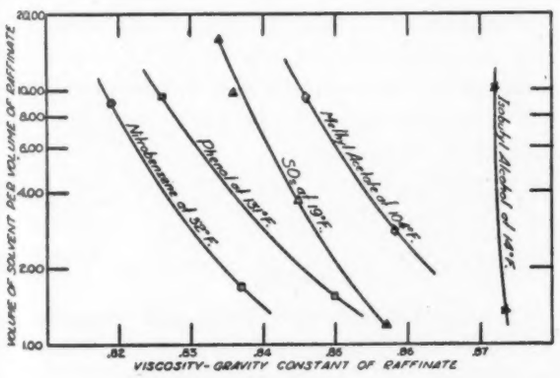

FIGURE 3

Comparison of Selective Solvents:
(b) *Overall Efficiency*

Figure 3 shows the volume of each solvent necessary to produce one volume of a raffinate of any given quality.

The significance of these charts may be summed up by comparing the volume of the solvent required to produce one volume of raffinate of three Viscosity Gravity Constants.

As stated, the foregoing results were obtained by single batch extraction. Counter-current extraction not only enables significant reductions in the amount of solvent necessary, but in addition increases the yield of raffinate, and enables the separation of oils of higher paraffinicity than is possible with single batch extraction. The comparison between the two methods is shown quantitatively for nitrobenzene in Figures 4 and 5. The "multiple" extraction curves shown are only of laboratory interest — the procedure being treatment of the raffinate or nitraffin from the first extraction with fresh solvent, and repetition of this procedure. It is striking that in place of the 550 volumes of nitrobenzene necessary to treat 100 volumes of stock to produce a 0.810 V.G.C. raffinate by the single application, but 100 volumes were necessary in a three-stage counter-current treat, and that the yield of raffinate was increased from 10 to 27 per cent. The improvement by multiplication of stages beyond three is comparatively insignificant (*Note*—When nitrobenzene is the sole solvent referred to in what follows, the terms "extract" and "raffinate" are replaced by "nitrene" and "nitraffin.")

TABLE I

Comparison of Selective Solvents

	Volumes* of Solvent required to produce One Volume of Raffinate of V.G.C. of:		
	0.860.	0.840.	0.820.
Nitrobenzine	0.5	1.4	8
Phenol	0.9	3.0	18
Sulphur dioxide	0.9	6.5	impossible
Methyl acetate	2.3	21	impossible
Isobutyl alcohol	impossible	impossible	impossible

*By batch extraction.

The temperature at which an extraction is carried out affects the results obtained and has an important bearing on plant design. In general it has been found that the optimum temperature will lie at least 40° F. below the miscibility temperature of stock and solvent.

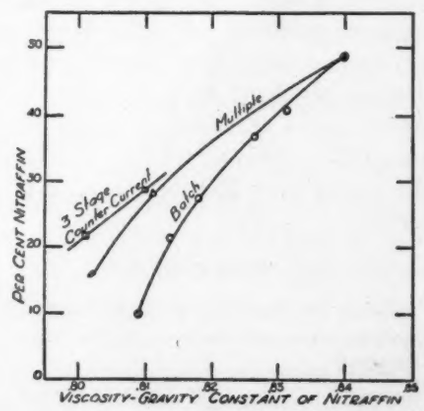

FIGURE 4

Comparison of Extraction Procedures:
(a) *Nitraffin Yield*

As the temperature is lowered two opposing effects are observed—the difference in solubility between paraffins and naphthenes increases, tending to increase the yield of an oil of given paraffinicity per volume of stock and

the actual solubility of both decreases, tending to decrease the yield per volume of solvent. The determination of optimum extraction temperature will therefore depend upon the amount of stock available and the various cost factors involved—solvent losses, refrigera-

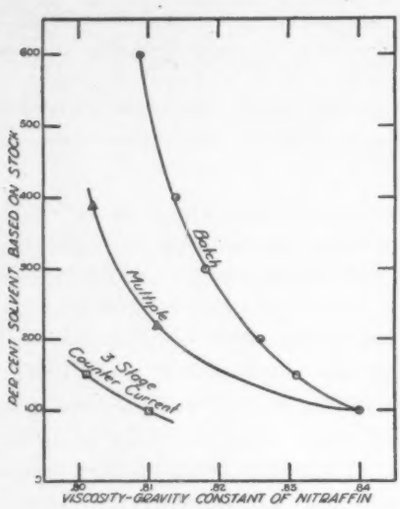

FIGURE 5

Comparison of Extraction Procedures:
(b) *Volume Efficiency*

tion, capacity, etc. With nitrobenzene the temperatures vary from about 30° F. for a highly naphthenic to 120° F. for a highly paraffinic stock.

The solvent which is applicable to the widest variety of charge stocks has an obvious advantage. Nitrobenzene boiling at 410° F. is readily separable by distillation from substantially all lubricating stocks; furthermore, its gravity and solubility characteristics are such that high settling rates between two layers are obtained with the heaviest of residuums. In other words, it is applicable to the entire range of lubricating stocks. Further, it is one of the few materials which retains its solvent power as the molecular weight of the stock rises, and is, therefore, capable of producing highly paraffinic fractions even from crude residuals. Table II gives results obtained on stocks of viscosities ranging from 152 seconds at 100° F. to 632 seconds at 210° F., the stocks over 200 seconds at 210° F. being crude residuals:

TABLE II

Variation in Viscosity of Charging Stock

CHARGE			Nitrobenzine, %.	"Nitraffin" Yield, %.	Finished Oil V.G.C.
Saybolt Viscosity		V.G.C.			
At 100° F.	At 210° F.				
152	—	0.844	120	30	0.804
305	—	0.853	100	49	0.811
612	—	0.874	150	22	0.801
—	77	0.856	125	53	0.810
—	178	0.863	150	52	0.812
—	275	0.895	150	21	0.798
—	379	0.861	250	26	0.813
—	632	0.888	100	40	0.806

Table III illustrates the versatility of the solvent with reference to crude source of the stock from extreme naphthenic to extreme paraffinic, and the relative uniformity of the products from all.

TABLE III

Variation in Paraffinicity of Charging Stock

Charge, V.G.C.	Nitrobenzene, %.	"Nitraffin" Yield, %.	Finished Oil, V.G.C.
0.895 Residual	100	20	0.803
0.880 Distillate	125	33	0.802
0.874 "	150	22	0.801
0.864 "	100	41	0.810
0.857 "	200	41	0.807
0.844 "	120	30	0.804
0.817 "	60	74	0.801
0.808 Residual	50	80	0.800

Table IV shows for three stocks the relation between the amount of nitrobenzene used and the paraffinicity of the product.

TABLE IV

Variation in Nitrobenzene—Oil Ratio

Nitrobenzene, %.	Charge, V.G.C.	"Nitraffin" Yield, %.	Finished Oil, V.G.C.
150	0.889	24	0.817
200	—	21	0.801
53	0.853	55	0.817
100	—	49	0.811
136	—	44	0.807
185	—	38	0.804
375	—	28	0.799
50	0.808	80	0.800
100	—	47	0.792
350	—	28	0.779

Examination of Tables III and IV will show that in general the production of oils of V.G.C. equal to the highest type of Pennsylvania oils will require from one to two volumes of nitrobenzene per volume of stock depending upon its character.

The nitraffin invariably has a lower viscosity than the charge, and the extent of the change is indicated in Table V.

TABLE V

Viscosity Differences of Charge and "Nitraffin"

CHARGE			FINISHED OIL			"Nitraffin" Yield
Saybolt Viscosity		V.G.C.	Saybolt Viscosity		V.G.C.	
At 100° F.	At 210° F.		At 100° F.	At 210° F.		
152	—	0.844	109	—	0.804	30
305	—	0.853	208	—	0.817	55
			200		0.811	49
			185		0.807	44
			172		0.804	38
			165		0.799	28
	94	0.860		80	0.823	49
	136	0.859		93	0.818	54
	275	0.895		105	0.798	21
	382	0.878		120	0.809	36
	557	0.880		279	0.829	43

In all four tables the values given are the result of three-stage counter-current extraction. The properties

of the finished oils were determined after finishing to specification color and pour.

The extent to which a solvent removes color has an important bearing on the cost of producing marketable oils. Nitrobenzene is peculiarly effective in this respect, since for highly paraffinic nitraffins clay filtration alone is effective in producing oils of stable color and the cost of acid treating and incidental oil losses may be eliminated.

Wax is, of course, relatively insoluble in nitrobenzene, and is concentrated in the nitraffin. Oils having a pour point over 100° F. may cause difficulty in separation of the two layers during extraction, and partial pre-dewaxing may be advisable.

The general improvement in quality, not only with reference to paraffinicity, but also flash point and carbon residue, is shown in Table VI. The three stocks cited and the nitraffins produced therefrom were treated by identical methods. The very small carbon residues of the distillate nitraffins is noteworthy.

TABLE VI

Improvement in Quality of Oil

	Viscosity at 210°F.	V.G.C.	V.I.	Flash Point °F.	Carbon Residue
Mid-Continent:					
Distillate	69	0.852	83	475	0.46
Distillate "nitraffin"	67	0.811	102	490	0.11
Coastal:					
Distillate	84	0.850	47	455	0.53
Distillate "nitarffin"	85	0.803	89	520	0.07
Coastal:					
Residuum	159	0.863	—	500	1.0
Residue "nitraffin"	151	0.830	—	535	0.5

The production of a high-grade motor oil from a coastal distillate is illustrated in Table VII. The stock was extracted with 1.4 volumes of nitrobenzene per volume of stock, and the extraction temperature ranged from 50° F. in the first stage to 77° F. in the third.

TABLE VII

Production of High-Grade Motor Oil

INSPECTIONS	Charge	"Nitraffin"	"Nitrene"	Motor Oil
Gravity, ° A.P.I.	20.2	26.6	14.6	27.1
Saybolt viscosity at 100° F., seconds	—	—	—	1.038
Saybolt viscosity at 210° F., seconds	136	95	245	94
Viscosity-gravity constant	0.859	0.816	0.897	0.813
Viscosity Index	—	—	—	101
"Parvis" temperature, °F.	—	—	—	2
True color	2320	474	4500	4
N.P.A. color	—	—	—	1¾
Pour Point, °F.	60	100	—	35
Flash Point, °F.	495	500	—	505
Fire Point, °F.	595	585	—	590
Conradson Carbon, per cent	—	—	—	0.01
Ash, per cent	—	—	—	0.002

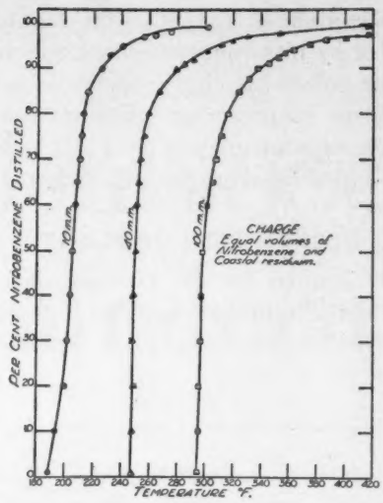

FIGURE 6

Recovery of Nitrobenzene from Oil Mixtures

Nitrobenzene is an oxidizing agent, and a great deal of work has been done and a variety of methods used to determine the extent of its reaction with lubricating oils. No reaction occurs at temperatures up to 300° F.; at 350° F. a slight reaction takes place, but to an insignificant extent so far as losses are concerned; at 400° F. reaction is positive. Vacuum must therefore be used in the removal of this solvent, since it boils at 410° F.; it is advisable that the heating means be closed coil steam at, say, 150 pounds gauge pressure (366° F.), so that temperatures at the heating surfaces sufficiently high to cause reaction are entirely precluded. Figure 6 shows the temperatures at three subatmospheric pressures attained during the removal of the nitrobenzene from equal volumes of the solvent and a coastal residuum, and shows that no difficulty will be encountered in practice in operating at temperatures well below the reaction point.

While, as was stated in the introduction, solvent processes are aimed primarily at the production of motor oils, their potential field is much wider. Conventional refining processes remove the undesirable constituents of a lubricating oil mainly in the form of acid sludge, often a liability rather than an asset. Selective solvents effect no chemical changes in the oils resulting from the treatment. They offer to the refiner a means of fractionation in a different direction than obtained by distillation; from any oil a number of fractions may be obtained of widely differing characteristics. The nitrenes from nitrobenzene extraction used as a cracking stock give gasoline of higher detonation value than that obtained from the stock. Fractions from certain stocks both more paraffinic and more naphthenic than the stock itself have shown unusually high electrical resistivity, and in some cases the remarkable characteristic of a higher resistivity after exposure to air at 100° F. for 72 hours than before. Oils which are to be used in direct contact with liquid SO_2 in refrigerators are required to

dissolve a minimum of the SO_2; the highly paraffinic oils obtainable by nitrobenzene are exceptional for this purpose. The color-removing property of nitrobenzene affords a means of preparing white oil stocks and of avoiding the enormous usage of acid and losses of oil as sludge now experienced in their manufacture.

DESCRIPTION OF PLANT

The plant required for the process consists of two parts: (1) the continuous five-stage counter-current extractor, in which the charge oil is separated into the

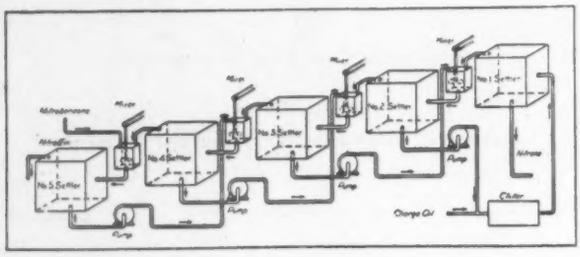

FIGURE 7
Diagram of Counter-current Extractor

"nitraffin" and "nitrene" fractions; and (2) nitrobenzene recovery system, which consists of an evaporator-condenser and a steam stripper for each of the two products from (1), together with a nitrobenzene absorption tower for scrubbing the gases passing to the vacuum pump.

The extractor consists of five rectangular settlers, each of which provides approximately one hour of settling. The general arrangement of the stages is shown conventionally in Figure 7. The inter-stage mixers are so placed that the "nitraffin" (usually waxy) layer from one stage flows over a weir into the mixer, is there mixed with the "nitrene" from the second succeeding stage, the mixture passing from the bottom of the mixer into the intermediate settler. This process is repeated throughout the system, as the diagram illustrates. The interface level in each settler is automatically controlled by the gravity differential of the layers. The "nitrene" layer, which is at all times fluid, is transferred from one stage to another by low-head centrifugal pumps.

The essential flow chart of the entire plant is given in Figure 8. The "nitrene" removed from the first stage of the extractor A is heated to 220° F. by exchangers, and then passes to the "nitrene" evaporator-condenser B, in which all but one per cent of the solvent is removed as the solution passes down through the six sections wherein the temperature of the oil is gradually raised to a maximum of 300° F. The complete removal of the nitrobenzene is accomplished in steam stripper *C* at a maximum temperature of 350° F. The absolute pressure maintained in the former unit ranges from 10 mm. to 30 mm., and is 50 mm. in the latter.

The "nitraffin" discharged from the fifth stage of the

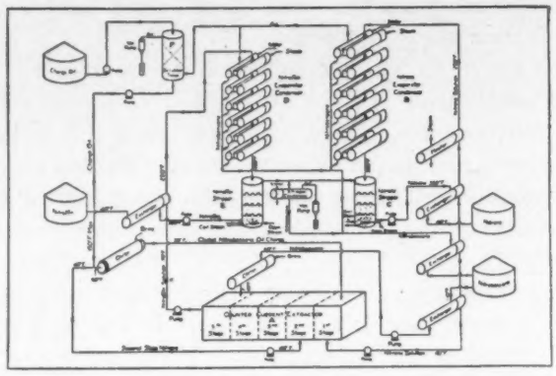

FIGURE 8
Flow Chart of Nitrobenzene Plant

extractor is similarly handled in the "nitraffin" evaporator-condenser *D*, and the stripper *E*. The product is then ready for subsequent treatment required for producing the finished oil. The exit gases from both *B* and *D* are scrubbed by the incoming oil in *F* before passing to the vacuum pump.

The cost of operating a nitrobenzene extraction plant will vary widely with the character of the stock and the quality of the product desired, since the amount of solvent used per volume of nitraffin obtained is the determining cost factor. The major single item of expense, however, is the nitrobenzene loss, which estimated at 0.2 per cent may represent about 40 per cent of the total. The sources of nitrobenzene loss and their extent, based on the volume of nitrobenzene charged, are:

1. Plain leakage and evaporation from pumps, gaskets, etc. This can and must be cut to negligible quantities.	
2. Decomposition in evaporator	0.06%
3. Nitrobenzene content of stripped products	0.01%
4. Solution in condensate from strippers...	0.004%
5. Vacuum pump exhaust after scrubbing...	0.01%
Total loss	0.084%

CONCLUSION

It can safely be said that of the known solvents for the purpose here discussed, nitrobenzene is unique in its versatility—in its ability to produce from any lubricating stock from residuums to light distillates and from extreme naphthenic to Pennsylvania crudes, oils of super-paraffinicity, having high resistance to oxidation and low carbon-forming characteristics.

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Combination Refining Plant *at Whiting* Unique in Modernity

J. V. JIRASEK

SUMMARY

THIS article gives a brief description of the 19,000-barrel combination topping, cracking and stabilizing unit recently completed by the M. W. Kellog Company at the refinery of Standard Oil Company (Indiana) at Whiting, Indiana.

This unit has now been in operation for about six months, processing approximately 20,000 barrels per day of Mid-Continent crude, and producing 70 per cent by volume of stabilized gasoline having an octane number of 70 or better.

In one single installation are combined the operations of topping, viscosity breaking, naphtha reforming, vapor-phase cracking and gasoline stabilizing.

The article gives a brief description of the unit, the approximate size of various pieces of equipment, and is accompanied by diagrammatic flow sheet, furnace sketches, and ground plan of plant.

This paper was read before the World Petroleum Conference, London, England, July 19-25, 1933, under the title: "Combined Crude Topping, Viscosity Breaking, Vapor-Phase Cracking, Naphtha Reforming and Gasoline Stabilizing Unit for Standard Company (Indiana), Whiting, Indiana."

THE M. W. Kellogg Company has recently completed and put into operation what is probably the most unique refining unit now in operation in any oil refinery.

The economic conditions in the oil refining industry during the past few years have demanded that oil refining be placed on a strictly manufacturing basis, and the present plant was designed to produce gasoline suitable for the present-day market, at the minimum unit cost.

It was designed and built for Standard Oil Company (Indiana) to process 19,000 barrels of Mid-Continent crude, and to produce therefrom a stabilized gasoline of a high octane number.

This unit has now been in operation for more than six months, processing 20,000 barrels per stream day of 36-37° A.P.I. Mid-Continent pipe line crude, and producing therefrom 70 per cent of stabilized gasoline having an octane number of 70 and showing approximately 18 per cent off at 158° F. by the A.S.T.M. distillation method. The distillation curve of this gasoline is shown in Figure 1.

The fuel oil has a flash of over 300° F. and a viscosity of below 200 sec. Saybolt Furol.

DESCRIPTION

The operations of crude topping, naphtha reforming, viscosity breaking and vapor-phase cracking, together with gasoline stabilizing, have been combined in this plant so that all operations are carried on simultaneously.

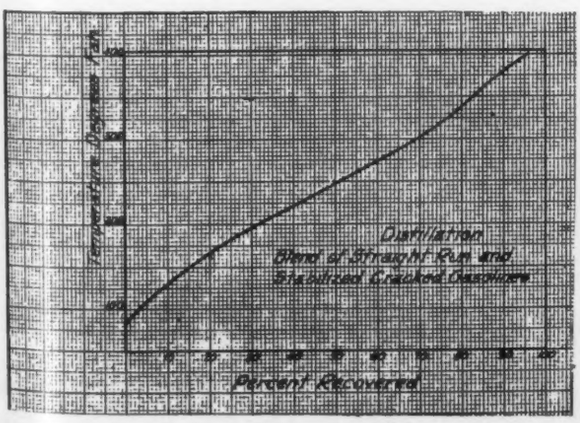


FIGURE 1.
Distillation Curve of Gasoline

While all operations are carried on concurrently, the unit is sufficiently flexible so that every operation can be independently controlled and conducted under the most suitable conditions of temperature and pressure to achieve the desired result.

The topping operation, which is accomplished entirely by waste heat, removes a light fraction of straight-run gasoline, a heavy naphtha fraction, and a light gas oil fraction.

The light straight-run gasoline has a gravity of approximately 70° A.P.I. and an end point from 300 to 325° F.

The naphtha fraction is charged directly to the reforming coil in the vapor-phase furnace.

The light gas oil fraction is pumped to the high pressure fractionating system where it eventually forms part of the charging stock to the vapor-phase furnace.

The topped crude passes to the upper section of the fuel oil flash tower where it combines with the

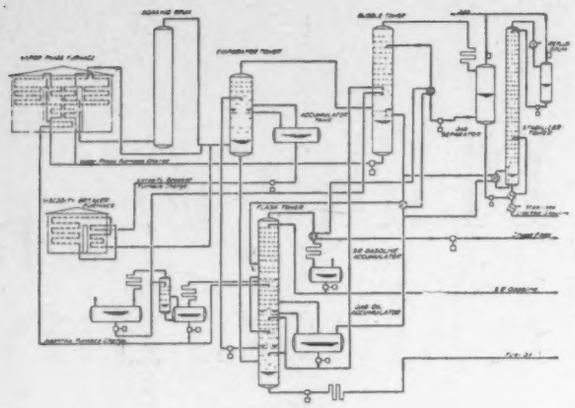


FIGURE 2.

Flow Diagram of 19,000-Bbl. Topping, Cracking, Reforming and Stabilizing Unit.

heavier cycle stock. The combined feed is then pumped to the high pressure evaporator for additional direct heat exchange and then flows to the viscosity breaker accumulator, from which it is pumped to the viscosity breaking furnace. This furnace is operated so as to produce some cracked gasoline and a suitable charging stock for the vapor-phase portion of the unit.

The vapor-phase charging stock is fractionated out in the high pressure bubble tower and accumulates in the bottom section, from which it is drawn by means of a hot oil pump and circulated through the vapor-phase furnace. The lighter ends are removed from this stock by stripping with water.

The fuel oil formed from the primary and secondary cracking operations accumulates in the bottom of the high pressure evaporator, from which it is drawn to the combination fuel oil flash and crude topping tower operated at low pressure. Here the fuel oil is flashed to the desired gravity and viscosity before passing from the system.

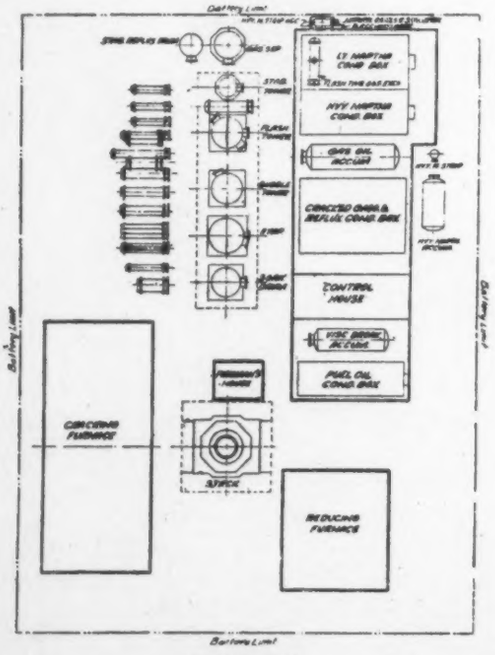


FIGURE 3.

Ground Plan for 19,000-Bbl. Combination Unit

The flash distillate from the fuel oil passed to the second section of the fuel oil flash tower, where direct heat exchange takes place with the topped crude, the heavy distillate condensed, and carried along with the topped crude, while the light distillate suitable for vapor-phase charge stock passes overhead to the third section of this tower, from whence it is returned to the high pressure fractionating system together with the virgin light gas oil fraction of the crude previously mentioned.

All of the cracked gasoline and gas from the three operations of naphtha reforming, viscosity breaking, and vapor-phase cracking passes from the top of the high pressure bubble tower to the high pressure gas separator. This separator is so operated as to release a dry gas from the top of a low butane and heavier content.

The raw gasoline is pumped from the bottom to a high pressure stabilizer. Here the remaining fixed gases are released and a stabilized gasoline of the desired vapor pressure is drawn from the bottom.

See Figure 2, flow diagram, Figure 3, ground plan.

OPERATING CHARACTERISTICS

This unit is extremely stable and steady in operation, and under the operating conditions outlined above will remain on stream 25 days.

The fixed gas is low for the character of the gasoline produced, being approximately 700 cubic feet per barrel of cracked gasoline.

The fuel consumption is approximately 5½ per cent based on the crude charge.

Only four men are required per shift to operate the entire plant, although five are being used at the present time because it is comparatively a new unit.

INSPECTIONS

Typical distillations of the feed and products are as follows:

	Crude feed	S.R. gasoline	Stabilized cracked gasoline	Blend of S.R. and cracked	Residue
Gravity A.P.I.	37.0°	70.4°	58.6°	61.2°	8.0°
I.B.P.	140° F.	83° F.	93° F.	84° F.	
10%	226	127	130	126	
20%	310	154	164	160	
30%	392	175	200	192	
40%	474	195	234	221	
50%	559	210	261	245	
60%	650	224	287	270	
70%	—	239	314	300	
80%	—	261	341	334	
90%	—	296	374	374	
E.P.	—	318	406	403	
% over at 158°F.	—	28%	22%	23.5%	
Octane number	—	59.5	72.0	70.0	
Flash	—	—	—	—	315°F
Viscosity S.F. at 122°F	—	—	—	—	187″

(*Continued on page* 339)

Transition from Shell to Tube Still Not Yet Complete

GEORGE REID
Associate Editor

IMPROVEMENT in manufacturing facilities in the refining industry is continuing this year through installation of modern tube still distillation equipment for running crude and redistillation work, and through continued activity in cracking unit erection.

Present activity in construction work can not be attributed solely to competitive conditions in the marketing branch of the industry, nor to the need for high anti-knock value motor fuels by present day motors. To be sure, these factors continue to influence conditions to some extent, but primarily the cause for construction of new refinery equipment is that of competition between modern and obsolete manufacturing facilities.

Running at about 65 to 70 per cent of its rated operative capacity of practically 3,600,000 barrels per day, the industry easily takes care of present demands for motor fuel and all other products. Approximately 375 operating plants can easily increase the percentage of operating capacity to take care of any improvement in demand. Further, there are about 135 shut down refineries with total capacity of around 450,000 barrels per day, and there is a like amount of shut down cracking capacity.

Of the new refineries which have been added this year, some of which are now building, the larger installations have been or are being erected to satisfy certain needs peculiar to conditions prevailing with companies already established in the industry. The smaller plants, largely located in East Texas, have added but little to total capacity of all refineries. From the viewpoint of economic importance and permanence but few of the year's projects in new refineries need be given serious consideration.

The principal factors contributing to erection of new installations are those of replacement of obsolete equipment in both the field of distillation and that of cracking and prevailing low prices of equipment and materials. The second factor of low priced equipment has no doubt influenced many companies in their decision to replace worn-out and obsolete distillation facilities and to expand their cracking departments during this year. The old battery of shell stills, of which there are many more operating than is generally believed, simply can not compete on an efficiency basis with modern tube still and fractionating equipment. Neither can the cracking unit of 8 to 10 years ago compete with presently available modern cracking facilities. Further, those early cracking installations are for the greater

TABLE 1

New Tube Stills Reported Since January 1, 1933, (over 500 barrels daily capacity). (Not including Cracking Units—See Table 5)

COMPANY	Capacity	Type
Associated Oil Company, Associated, California	6,000	Rerun
Falcan Refining Company, Great Bend, Kansas*	800	Crude
Phillips Petroleum Company, Kansas City, Kansas	5,000	Crude
Cities Service Refining Company, East Braintree, Massachusetts	2,500	Crude
Allegheny Refiners, Inc., Boliver, New York*	750	Crude
Cresent Refining Company, Holdenville, Oklahoma*	1,000	Crude
Bradford Oil Company, Bradford, Pa.	1,500	Crude
Canfield Oil Company, Coraopolis, Pa.	1,200	Crude
W. H. Daugherty & Sons Refining Company, Petrolia, Pa	2,000	Crude
Gulf Refining Company, Neville Island, Pa	5,000	Crude
Oil Creek Refining Company, Titusville, Pa	1,500	Crude
Pure Penn Refining Company, Clarenden, Pa	1,000	Crude
Quaker State Oil & Refining Company, Oil City, Pa	2,500	Crude
Sloan & Zook Refining Company, Warren, Pa	1,500	Crude
Wolverine-Refining Company, Reno, Pa	1,000	Crude
Bee Refining & Producing Company, Pettus, Texas*	1,000	Crude
Coltex Refining Company, Colorado, Texas	2,000	Crude
Cosden Oil Company, Big Springs, Texas	5,000	Comb.†
McNutt Oil & Refining Company, El Paso, Texas*	1,000	Crude
Pan American Refining Corp., Texas City, Texas*	25,000	Comb.†
Rusk Gasoline Company, Overton, Texas*	2,500	Crude
Shamrock Oil & Gas Company, Lefors, Texas*	1,200	Crude
Tyler Refining Company, Arp, Texas*	1,000	Crude
White Star Refining Company, Cisco, Texas*	1,000	Crude
Wichita Refining Company, Wichita Falls, Texas*	500	Crude
H. F. Wilcox Oil & Gas Company, Pampa, Texas	2,500	Crude
Continental Oil Company, Glenrock, Wyoming	3,000	Comb.†

*New Refineries. †Crude and Crack.

part past their age of safe usefulness and must be replaced.

EIGHTEEN NEW PLANTS

Eighteen new refineries were reported under construction January 1, 1933, with capacity aggregating 31,545 barrels. Of these, Gulf Refining Company's Staten Island, New York, plant, Dickey Oil Company and Globe Oil & Refining Company's refineries at McPherson, Kansas, were the most important commercially. Fourteen of the 18 plants reported were too small to be of commercial importance, several of them being less than 100 barrels capacity. July 15 reports show that an additional 11 new refineries, over 500 barrels capacity, have been erected or are now under construction. The most important of this group is the new refinery of Pan American Refining Corporation (Standard Oil Company (Indiana) subsidiary) now under construction at Texas City, Texas. This plant and the other 10 new plants are listed in Table 1, tabulating the new tube stills reported to July 15.

As an indication of the importance of present activity and the further adoption of the modern tube still in distillation work replacing the shell still battery, records show that on the first of the year eight tube still units were in course of erection. During the first half of the year 1933, 27 additional tube stills have been or are being installed; total capacity about 80,000 barrels.

An interesting fact appears in the work of G. R. Hopkins and E. W. Cochrane of the Bureau of Mines in Information Circular 6728, "Petroleum Refineries, Including Cracking Plants, in the United States," which reads as follows:

"The survey of January 1, 1933, included for the first time information as to pipe stills used in straight distillation. This canvas showed that there were 685 such stills used at refineries in the United States, 569 of which were operating on January 1, 1933. Of the operative pipe stills, 353 were operating on crude, 69 on lube stocks, 75 on pressure distillate, and 72 on 'other oils.' The total daily charging capacity of all the pipe stills was 2,959,579 barrels, of which 2,443,556 barrels, or 83 per cent, was operative on January 1, 1933. Complete data as to the capacity of the pipe stills operating on crude were not obtained, but it is estimated that the total was equivalent to about 50 per cent of the crude oil capacity of the operating refineries."

Since the first of the year 31 new tube stills have been added and placed in operation, bringing the total to 600 operating tube stills and increasing the number operating on crude oil from 353 to 382, since 29 of the new stills have been placed in that service. In the Pennsylvania refining district which has long been the stronghold of the shell still battery, tube still erection has been especially active this year and nine companies have installed or are now erecting as many modern distillation units. Of the total of 44 refineries only 10 remain not now equipped with tube stills for distillation work. In the Pennsylvania district one new refinery is under construction—Allegheny Refiners, Inc., complete plant, at Bolivar, New York.

CAPACITY OF STILLS

Based on Bureau of Mines figures as shown in Table 2, Recapitulation of Pipe Stills by Districts, the average capacity of such stills is 4320 barrels, the average capacity of all operating tube stills is 4294 barrels, and the average capacity of the 108 shut down tube stills is 4474 barrels. These figures are of interest only in that they show average capacities of tube stills in distillation service to be approximately twice the average capacity of operating cracking stills, which is 2382 barrels per unit.

Estimating that the refining industry should process around 2,300,000 barrels of crude daily as an average figure, then the 382 tube stills to which crude oil is charged, handle about 1,150,000 barrels per day on the basis of the Bureau of Mines estimate of 50 per cent. This gives an average charging rate for this class of tube stills of around 3000 barrels. Actual capacities,

TABLE 2

Recapitulation of Pipe Stills by Districts (January 1, 1933)

DISTRICT	Number[1]				Number[2]				Capacity (Barrels per day)			
	Op.	S.d.	Bldg.	Total	Crude	Lubes	Press. Dist.	Other Oils	Op.	S.d.	Bldg.	Total
East Coast	81	9	2	92	45	12	14	10	462,790	40,000	17,000	519,790
Appalachian	46	4	.....	50	22	15	6	3	139,500	5,500	.....	145,000
Ind., Ill., Ky., etc.	54	9	1	64	33	5	7	9	322,700	51,500	1,500	375,700
Okla., Kans., Mo., etc.	85	19	3	107	42	11	17	15	353,450	72,375	14,000	439,825
Texas Inland	73	12	1	86	44	7	6	16	165,600	47,900	350	213,850
Texas Gulf Coast	51	3	.....	54	41	5	2	3	310,500	25,000	.....	335,500
Louisiana Gulf Coast	18	6	.....	24	16	1	1	0	115,000	27,000	.....	142,000
Ark., & La., Inland	11	1	1	13	10	1	.....	.....	44,000	13,300	.....	57,300
Rocky Mountain	35	8	.....	43	20	2	6	7	59,356	13,948	.....	73,304
California	115	37	.....	152	80	10	16	9	470,660	186,650	.....	657,310
TOTAL	569	108	8	685	353	69	75	72	2,443,556	483,173	32,850	2,959,579

[1]Number according to status of operation.
[2]Number in operation according to charging stock.
Source—Bureau of Mines, information Circular No. 6728

of course, range from 1000 to 15,000 and 20,000 barrels per day per unit.

However, the foregoing estimation indicates that there remains sufficient batteries of shell stills in refinery yards and in operation to process well over a million barrels of crude daily. These batteries are being dismantled as they become worn out or as economic conditions justify. Taking the average of present day installations as an index to future capacities per unit, it seems conservative to estimate that from 150 to 200 more tube still units will be required before the practice of distilling through shell still batteries is eliminated. Inasmuch as the majority of such shell still batteries are in service in the refineries of the larger intergrated oil companies, there is assurance that they will be replaced with tube still units in the next few years, for these larger companies have been rather aggressive in their modernization programs. The majority of such units will, it is believed, be of the new combination crude skimming and cracking still type, performing both the distillation of natural products and the preparation of synthetic products simultaneously in the same system.

CRACKING

During the year expansion in the cracking field has been steadily going forward. Production of cracked gasoline at this time is above any previous figure. In July, 1932, the Bureau of Mines began including figures as to charging stock charged to cracking stills, gasoline production, and fuel oil produced by cracking, in its Monthly Petroleum Statements. The trend in cracked gasoline production is reflected by the data presented in Table 3, which is the statistical history of cracking operations since such data has been available monthly. Inasmuch as June and July figures are not available from the Bureau of Mines at the time of this writing, the cracked gasoline production estimates for these months are taken from the weekly A. P. I. Economics Reports. The tabulation indicates that this year, despite continued depressed economic conditions and the availability of tetra ethyl lead for regular grades of gasoline, the production of cracked gasoline continues to increase and the operation of cracking units continues to become an increasingly important factor in the business of petroleum refining. Faced with a popular demand for 65 to 70 octane rating motor fuel, with a trend toward increasing octane rating of third grade gasoline, and with a low priced fuel oil market, the refiner finds it an economic necessity to keep his cracking department in efficient operating and producing condition. The result is that more companies are now engaged in cracking than ever before, and many companies long experienced in the operation of cracking units are replacing worn out, unsafe and obsolete units with modern cracking or combination skimming and cracking facilities. On January 1, 1933, 10 companies reported construction of 11 cracking units. These are listed in Table 4. According to trade reports for the period between the first of the year and July 15, 11 additional companies have installed or are erecting 13

TABLE 3

Cracking Operations—Monthly and Daily Average Production of Cracked Gasoline as Reported by Bureau of Mines and A.P.I. Economics Report.

MONTH	Barrels Cracking Stock Charged to Stills	Barrels Gasoline Produced by Cracking	Barrels Daily Average	Barrels Fuel Oil Produced by Cracking
1932				
July	33,807,000	15,205,000	490,486	11,375,000
August	34,979,000	14,442,000	465,870	11,375,000
September	30,776,000	13,540,000	451,333	10,795,000
October	31,807,000	14,003,000	451,709	10,844,000
November	30,959,000	14,240,000	474,666	11,026,000
December	30,482,000	13,686,000	441,483	11,302,000
1933				
January	30,494,000	13,128,000	423,486	11,215,000
February	29,473,000	12,211,000	436,107	10,436,000
March	32,246,000	13,644,000	440,129	10,830,000
April	33,211,000	14,258,000	475,266	11,079,000
May	37,785,000	16,400,000	529,032	12,466,000

WEEKS—June and July	Weekly A.P.I. Reports	Daily Average Bureau of Mines Basis—estimated
Week Ending—June 3	467,000	500,000
June 10	473,000	520,000
June 17	476,000	525,000
June 24	467,000	515,000
July 1	452,000	500,000
July 8	477,000	540,000
July 15	503,000	565,000
July 22	492,000	555,000
July 29	484,000	545,000

TABLE 4

Cracking Units Under Construction as of January 1, 1933. From Information Circular I. C. 6728—Bureau of Mines.

	Capacity	Units
General Petroleum Corporation, Torrance, California	6,000	1
Lubrite Refining Corp. East St. Louis, Ill	800	1
Dickey Oil Company, McPherson, Kansas	1,500	1
Globe Oil & Refining Company, McPherson, Kansas	4,000	1
Shell Petroleum Corporation, Arkansas City, Kansas	2,400	2*
Sinclair Refining Company, Argentine, Kansas	5,000	1
Sinclair Refining Company, Coffeeville, Kansas	5,000	1
Quaker State Oil Refining Corporation, Farmers Valley, Pa	1,250	1
Sinclair Refining Company, Ft. Worth, Texas	4,500	1
Danciger Refineries, Pampa, Texas	3,200	1
TOTAL	33,650	11

*Rebuilding.

TABLE 5

Cracking Units, Building or Announced Since January 1, 1933

	Capacity	Units
H. H. Cross Company, Smackover, Arkansas	1,000	1
Associated Oil Company, Associated, California	5,000	1
Spartan Refining Company, Inc., Shreveport, Louisiana	7,500	2
Crew-Levick Company, Petty's Island, New Jersey	1,500	1*
Pure Oil Company, Toledo, Ohio	2,000	1
Marathon Oil Company, Bristow, Oklahoma	1,500	1
Marathon Oil Company, Ft. Worth, Texas	1,500	1
Constantin Refining Company, Overton, Texas	1,000	1
Cosden Oil Company, Big Springs, Texas	5,000	1
Pan American Refining Corporation, Texas City, Texas	25,000	1†
Trio Refining Corporation, Arp, Texas	1,000	1
Continental Oil Company, Glenrock, Wyoming	3,000	1
TOTAL	55,000	13

*Rebuilding. †Combination.

more cracking units. These appear listed in Table 5. This brings the total number of refineries now equipped with cracking facilities to 216, leaving, however, around 300 plants not now having cracking facilities. It is estimated that around 75 of these plants will eventually erect such equipment, but that at least half of the 300 plants are too small to give consideration to cracking unit installation.

The transition from shell still type cracking units to tube still units is virtually complete in the cracking field. Each year the number of such units as Burton, Isom, Fleming, Conerty and Snodgrass has been progressively less and the current survey of the cracking field indicates but few of such units listed as operating. They are being rapidly replaced by the modern type of cracking process.

A canvass of the cracking unit situation at present indicates a total of 1056 units, of which 357, or 33 per cent, are shut down. At the beginning of the year 11 cracking units with total capacity of 33,650 barrels was reported to the Bureau of Mines as building. Trade reports since that time indicate 13 more units with total capacity of 55,000 barrels under construction or announced.

Operating capacity at the beginning of this year totaled 1,580,051 barrels, with 33,650 barrels building, or a total now of 1,613,700 barrels operative capacity. With new work recently completed or now under way included, total capacity becomes 1,666,700 barrels. There is a total of 417,694 barrels of shut down capacity.

An analysis of the shut down capacity still carried on reports shows that 176 of the inoperative units are shell still types (79 Burton, 85 Isom, 12 others). The total capacity of this group is 123,000 barrels. The remaining shut down capacity is composed of pipe still units, numbering 181 and having a total capacity of 294,694 barrels. These figures indicate that of the total of 1056 cracking units reported only 699 units are operating.

In this field there is a total of 880 tube stills, and of this number 181, or 20.5 per cent, are shut down, leaving 699 tube stills working in cracking service and no shell still types operating. It may be safely assumed that the 123,000 barrels of shell still type cracking units will never again enter the operating lists and that of the 181 tube stills (294,694 barrels capacity) not more than half will again see operation.

In the cracking field, because of the severity of the service and the rapidity of technical development, obsolescence is particularly rapid and it is estimated that at least 100,000 barrels capacity annually is lost through this factor alone and that actual dismantling of old cracking units proceeds at the same rate; making it necessary for the industry to replace with new equip-

TABLE 6

Gasoline Production by Skimming and Cracking, Percentage Recovery and Crude Charged to Stills. First Five Months, 1933 and 1932. (Natural Gasoline not included).

MONTH	Straight-run Gasoline Total	% of Total Gasoline Output	Cracked Gasoline Total	% of Total Gasoline Output	Per cent Gasoline Total	Crude Oil Charged to Stills
1933						
January	15,118,000	49.6	13,128,000	43.0	42.7	66,093,000
February	13,705,000	49.5	12,211,000	44.1	42.5	61,042,000
March	16,087,000	51.0	13,644,000	43.2	43.7	67,984,000
April	15,820,000	49.5	14,258,000	44.7	43.7	68,822,000
May	16,470,000	47.6	16,400,000	47.4	44.2	74,340,000
1932						
January	16,629,000	50.4	13,981,000	42.3	44.5	68,715,000
February	15,780,000	50.5	13,598,000	43.5	46.0	63,814,000
March	16,488,000	51.9	13,381,000	42.1	43.6	68,502,000
April	17,675,000	53.4	13,420,000	40.6	43.5	71,131,000
May	17,385,000	50.3	15,090,000	43.6	43.5	74,669,000

ment about 200,000 barrels of cracking capacity each year.

In cracking, it may safely be said that the day of the shell still is over. In straight distillation, apparently but 50 per cent of capacity has been replaced by the tube still. However, it is interesting to note that over 1,000,000 barrels daily of the crude oil processed by the industry, much of the redistillation work and all of the cracking is performed by a total of only 1299 operating tube stills, 600 of which are in distillation work and 699 in cracking service.

The present activity in construction of all types of refining units, and such additional installation work as will be experienced during the next few years is not for the purpose of expanding already over-built capacity, but is, however, necessary because the various manufacturing units within the industry must compete in efficient operation, and therefore must take advantage of technical development and progress. The industry is adequately equipped, from the capacity viewpoint, to take care of any improvement in demand for its products, but it is not equipped with sufficient scientifically designed refining facilities to do so at a profit for, as indicated by presently available information, a large percentage of its equipment is now obsolete. A period of profitable operation will be followed by a period of active engagement in modernization, and those concerns which are financially able to do so are now taking advantage of present low material and equipment prices.

Combination Refining Plant at Whiting Unique in Modernity

(*Continued from page* 334)

MECHANICAL CONSTRUCTION

The general arrangement of the heating surface of the viscosity-breaking furnace is shown in Figure 5. This furnace is entirely steel encased and is designed for a heat release of 71,000,000 B.t.u. per hour.

The vapor phase and naphtha reforming furnace has two independent radiant sections with a common convection section. This furnace is also entirely steel encased, and is designed for a total heat release of 216,000,000 B.t.u. per hour.

The main tower system of the cracking unit operates at a pressure of 250 to 200 pounds, while the stabilizer operates at the higher pressure of 450 to 350 pounds.

All of these large towers, which weigh from 280,000 to 300,000 pounds each, together with the various smaller towers and accumulators, are of Kellogg master-welded construction and were manufactured in the plant of the company at Jersey City, N. J. These towers are all built to conform with Class I specifications, which include the X-raying of all seams, and are designed with sufficient corrosion allowance to provide a life of 10 years.

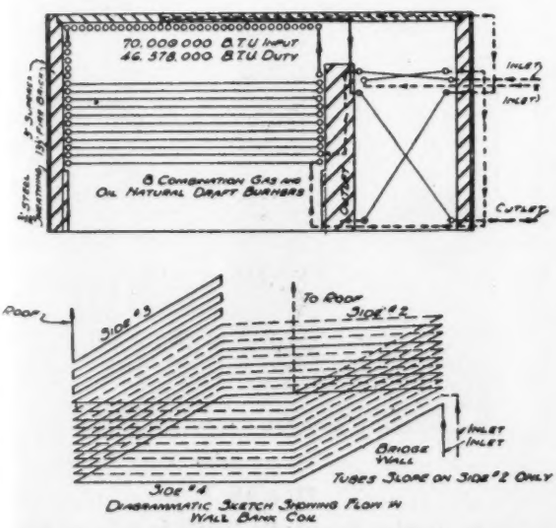


FIGURE 5.
Vapor-phase Cracking and Naphtha Reforming Furnace

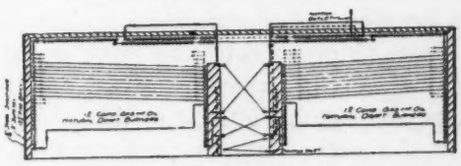


FIGURE 4.
Viscosity-breaking Furnace

The viscosity breaking charge pump has a capacity of 30,000 barrels per day, and the vapor phase charge pump has a capacity of 400,000 barrels per day, based on cold volume.

The quantity of 240,000 barrels of oil per day is pumped to this unit in the various stages of processing. With the exception of one or two smaller pumps, all of this oil is handled by means of centrifugal pumps. Most of the oil in process is pumped at a temperature of more than 500° F., and the volume handled by each of these pumps on a hot oil basis varies from 30,000 to 55,000 barrels per day. If reciprocating pumps had been used in the design of this plant, the pump house alone would have occupied more than three times its present ground space.

The operation of this unit has been so satisfactory in all respects that a second unit is now in process of construction, which will charge 32,000 barrels of East Texas crude per day and produce gasoline, kerosene, low cold test furnace oil and Bunker C fuel oil as products. In this new unit vapor phase clay treatment of the gasoline will be used, therefore the final product gasoline is substantially finished and ready for use.

Cleaning Refinery and Gasoline Plant Equipment

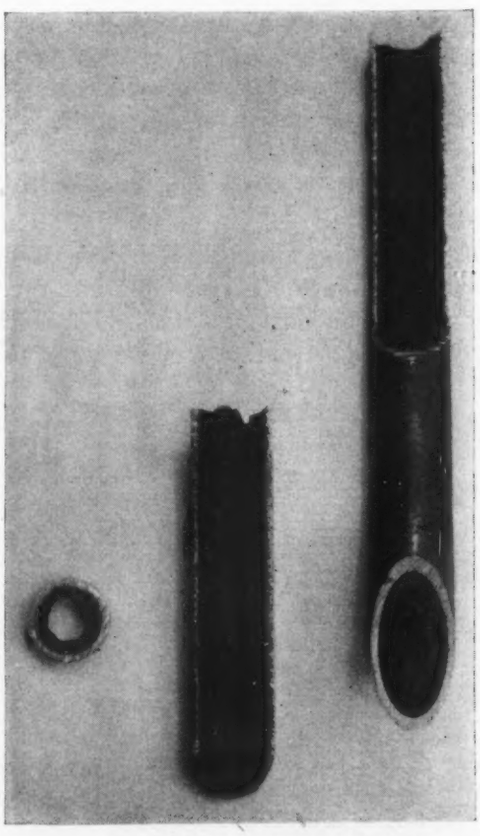
IN gasoline plant and refinery operation, more particularly in the heat transfer apparatus, an accumutalion of sludge, foreign matter and carbonized oil will form and adhere to the tubes, both inside and out, which if permitted to remain will seriously affect the results in passing a hot liquid in counter current to the cold and vice versa. In refineries, when the relatively heavy residuum removed from the flash chamber as reduced, crude is drawn away through heat exchange equipment to impart the acquired heat of process to the cold crude charge, some of the oil will carbonize and stick to the tubes and retard the passage of heat to the cold fluid. Not only will this occur, but the pressure drop through the units will increase, requiring more power to deliver a given amount through the equipment than when all passages are clear.

In gasoline plant practice, the mechanics are similar to refinery operation in that hot still bottoms consisting of stripped absorbing media is pumped, or perhaps evacuated from the still under process pressure through the heat exchangers. Exchangers are used in both instances to conserve the heat imparted to the oil, whether it is crude being distilled or mineral seal oil being stripped of the absorbed gasoline. The absorption oil, both hot and cold, will deposit a film of more or less hard carbonized oil on the surface of the tubes. The process of deposition is varied in its intensity, causing some plants to lose exchanger efficiency more rapidly than others, depending upon the type of oil handled, conditions under which the plant is operated and the temperature to which the oil is subjected.

FOULING OF TUBES

In exchanger equipment, the fouling of the tubes invariably begins on the side of the heavier material being processed, gradually becoming heavier and more impenetrable as time goes on until the exchange of heat is appreciably diminished. Not only does the hot oil passing out of the exchangers require more cooling water but the still requires more heat, requiring an excess amount of steam and fuel. If water is used as in cooling the residuum or mineral seal, scale is deposited more rapidly in these units due to the high temperature of the material leaving the exchangers. Scale varies in growth depending upon the quantity of scale forming minerals in the water, and as more water is required to cool the oil passing through the coolers, extra pump capacity must be provided. When the scale, sludge or carbonized residuum adhering to the tubes, either inside or out, becomes such that pump pressures are noticeably increased in delivering the required volume of fluid through the equipment, or the exchange of heat from one material to another becomes out of balance, it becomes necessary to clean a part or all of the equipment.

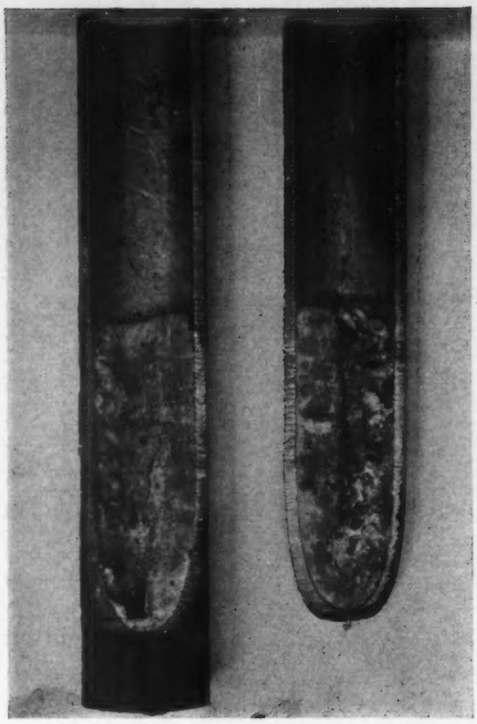
Often in operating a natural gasoline plant it will be found that the absorption towers are losing efficiency. Sometimes this is caused by an accumula-



—Courtesy Oakite Products, Inc.

FIGURE 1

Showing oil residue frequently found in tube of heat transfer equipment which deposits reduce heat transfer efficiency and increase back pressure on circulating pumps.



—Courtesy Oakite Products, Inc.

FIGURE 2

Type of water scale found in tubes of heat transfer equipment which reduced efficiency of the equipment.

tion of sludge, emulsified oil and foreign matter consisting of pump packing pulled through on the rods of oil pumps, scale and dirt not removed by the scrubbers. When this condition occurs, it seriously interferes with the mechanical mixing of the oil and gas and when the gas is not brought in intimate contact with the oil, some of the desirable fractions are carried out of the tower with the residue gas.

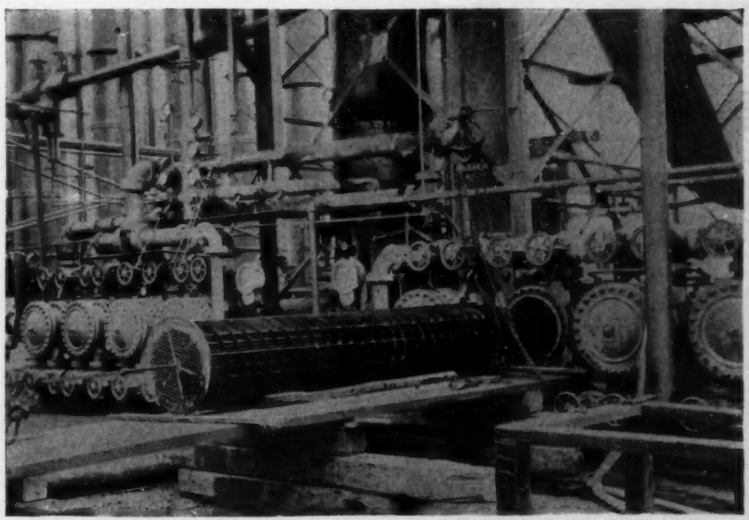
CLEANING EXCHANGERS

A number of methods are in use in cleaning exchangers. When the lowered efficiency is caused by a deposit of mineral scale in units utilizing water in cooling gas, oil, gasoline or residuum, many times the old strong arm method is applied. This method consists of holding an electric drill against the operator's shoulder while an extension bit slightly smaller than the tubes is driven through to remove the scale. This is a tedious job and presents the hazard of broken drill stems, scoring tubes and sidetracking the scale and puncturing the tubes. Often the scale is permitted to accumulate to such an extent that it is almost impossible to drive the cleaning tool through and if not cleaned for free passage of the cooling fluid, the exchanger or cooler is robbed of part of its functions. Workers assigned to the cleaning job often become careless, skipping tubes or not finishing those through which the drill has been passed.

Another method widely used is that of circulating hydrochloric acid in varying degrees of concentration through the units to break down and dissolve the "lime" scale in the tubes. Extreme precautions must be taken when using this method because when the solution is very dilute, the acid readily attacks iron. Numerous instances have been met with after repeated operations of this nature that bolts and dividing fins have been reduced to a soft, easily gouged out material, rendering it difficult to place and hold gaskets. In "boiling out" compressor power cylinders either in natural gasoline plants or vapor recovery units in refineries to remove the "lime" scale, the scale is sometimes mistaken by the operators to be "lime" when it consists largely of iron oxide and vegetable matter—as algae from the pits—with some oily waste gradually circulated with the water. If the major portion of the accumulation consists principally of "lime" the hydrochloric acid will break down the mass and the other matter will be washed out with the circulated chemical.

When the condition arises it is probably better to remove the heads and cover plates and take out the scale with tools made on the job in the shapes necessary to reach the difficult places. After the deposits have been broken away from the jackets, cover plates and heads, a stream of water should be used to flush away all sediment and loose material in the system. Other methods are available, various chemicals the character of which is determined in the formula by which they are manufactured and when used, they should be applied in the proper manner.

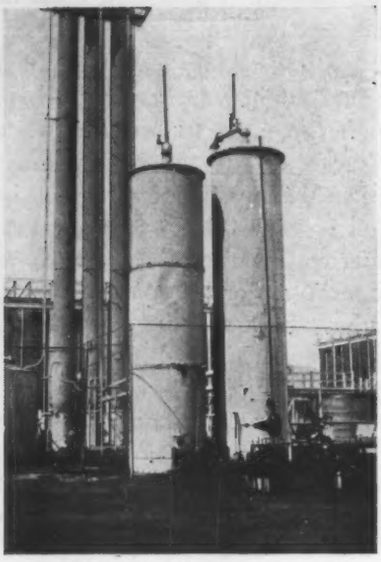
When removing sludge, burnt-on oil, and other matter reducing the efficiency of exchangers han-



—Courtesy Oakite Products, Inc.

FIGURE 3

Batteries of heat exchangers can be cleaned without dismantling by circulating cleansing solutions under proper conditions. One tube bundle in the battery shown has been pulled for inspection and photographing.



—Courtesy Oakite Products, Inc.

FIGURE 4

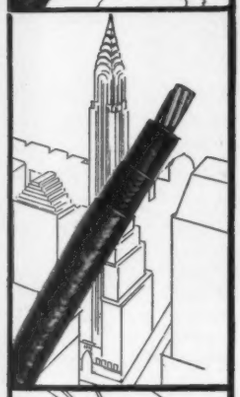
Clean absorbers are capable of handling more gas and with more efficient extraction of gasoline.

dling heavier hydrocarbons, mechanical cleaning is often employed, especially through the tubes. Swabs, gouges and slotted pipe are used, depending upon the inventive genius of the operators and the character of the deposits. Soft scale which wipes away easily can be removed with swabs, but that adhering to the outside of the tubes concealed by the shell of the unit is another matter. Often tube bundles are removable and when taken apart the tubes can be immersed in a vat containing a chemical cleaning solution, or streams of steam and hot water may be played upon them with sufficient force to penetrate within the bundle. Often the units are disconnected from the others and connections made to steam and hot water pipes with the water and steam driven through with sufficient velocity that the deposit is literally scoured away.

When the entire plant is fouled with incrusted deposits and burnt-on oil, sometimes chemicals are pumped through the unit to remove the sludge and other matter in one operation. One instance is that of a plant operated by Crosbie & Moran near Earlsboro, Oklahoma. The absorption oil side of the plant became clogged with sediment, and production could not be brought above 6000 gallons daily. Exchanger efficiency was lowered as well as the efficiency of the absorbers. The trays of the absorber and still had become partially filled with the deposits, and to remove all sediment and carbonized oil, a cleaning chemical was employed. Sufficient gallonage of the solution was made up to fill the system, handled by the piping and pumps in the mineral seal oil circulation system. Twenty-four hours were consumed in the operation, with a cash outlay for chemicals of $150.00. One day's production was lost consisting of 6000 gallons of gasoline, but when the plant was placed on production after being rinsed down, the gallonage was increased to 7200, an increase of 20 per cent.

National Refining Company, Coffeyville, Kansas, opearting a 5000-barrel skimming unit, found that pump pressures were steadily mounting and exchanger efficiency declining. On the hot oil from the flash tower, the temperature was normal at 510°F., but the same oil after passing through the banks of exchangers was running up to 264°F. Pump pressures had increased to 90 pounds in charging the crude to the unit. Cold oil from the pumps entered the exchangers at 58°F. and entered the still at 254°F. After cleaning the exchanger equipment and units with chemicals, hot oil from the still entered the exchangers at 510°F., but left them reduced to 192° F. At the same time, the cold oil entered the exchangers at 58°F., passing to the tubes of the stills at 368°F. Pump pressures declined to 65 pounds gauge to charge the same amount of oil as was processed before cleaning.

In both cases, an auxiliary tank was set in which the cleaning compound was mixed with hot water before passing through the units. In the gasoline plant, it required approximately 5000 gallons of solution to fill the system.



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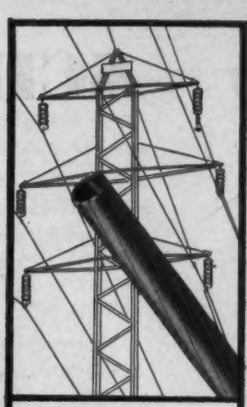

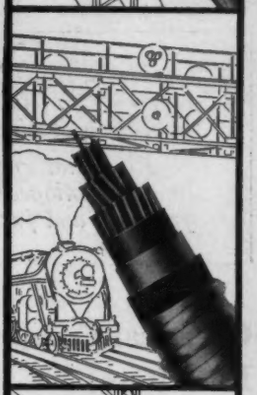

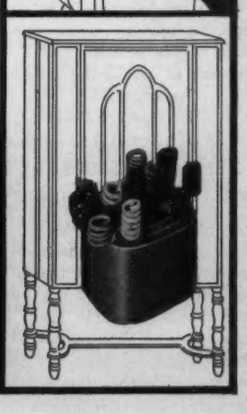

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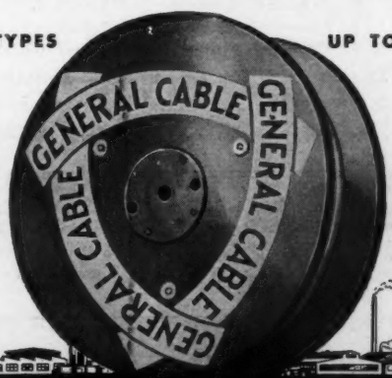

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by

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under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstract, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Chemical Composition and Reactions

The Estimation of Latent Heats of Vaporization. J. H. ARNOLD, *Ind. Eng. Chem.* **25** (1933) pp. 659-61.

The paper presents a method for the calculation of latent heats of vaporization of normal substances that is claimed to be valid under all conditions of temperature and pressure. The empirical rule of Hildebrand, as expressed by Lewis and Weber and improved by McAdams and Morrell, is shown to be an incomplete form of an accurate empirical equation of Dieterici and tested by Mills. Graphical study of the available data indicates that the Dieterici equation is reliable to 5% or better over the range of temperature from ordinary temperature to the critical point.

The Viscosity of Gases and Vapors. R. PLANK. *Forsch. Gebiete Ingenieurw. A or B, 4,* (1933) pp. 1-7.

The viscosity of ideal gases is independent of pressure. The equation of Maxwell and Sutherland has been used to determine the variation of viscosity with temperature, but this is being replaced by the equation of Trautz. Simple equations of state were developed for water and carbon dioxide.

Solubilities of Argon, Nitrogen and Hydrogen in Paraffin Oil. A. G. NASINI and G. CORINALDI. *Atti Soc. Ital. Progresso Sci* 20, **11** (1932) pp. 264-6.

The solubilities of the gases in an oil of 0.87 specific gravity were measured. Expressed as cc's of gas at 0°C. and 760 mm per 100 cc of solvent at 32°C., the solubilities are:

Argon 15.75
Nitrogen 7.36
Hydrogen 4.64

Standard States for Bomb Calorimetry. E. W. WASHBURN. *Bur. Standards J. Research* **10** (1933) pp. 525-58.

A study of the thermodynamics of bomb calorimetry shows that the heat of combustion per unit weight of substance burned is a function of the mass of sample used, of the initial oxygen pressure, of the amount of water placed in the bomb, and of the volume of the bomb. The manner of eliminating the effects of these variables is discussed. The correction may be as large as 0.5%, although it is usually less than 0.2%. Recommendations are presented covering the specifying of substances used as standards in bomb calorimetry.

Chemical Composition and Research

The Trimethyl Pentanes. K. C. LAUGHLIN and F. C. WHITMORE. *Journal American Chemical Society,* **55** (1933) pp. 2607-8.

The isomeric pentanes were prepared by hydrogenation of olefines derived from alcohols, using platinum oxide catalyst in methyl alcohol as a solvent. The reaction products in each instance were shaken with sulfuric acid to remove water, unchanged olefin, and alcohol, and fractionated at high reflux ratio. The properties of the four possible trimethyl pentanes are:

	Cottrell B.P. 760	N°_{D}	D^{20}_{4}
2, 2, 3, Trimethyl pentane	110.2	1.4030	0.7173
2, 2, 4 Trimethyl pentane	99.3	1.3916	0.6918
2, 3, 3, Trimethyl pentane	113.6	1.4074	0.7258
2, 3, 4, Trimethyl pentane	112.8	1.4045	0.7197

The Preparation of Pure 2, 4-dimethyl-1, 3-pentadiene. H. I. WATERMAN and W. J. C.DE KOK. *Rec. trav. chim.* **52** (1933) pp. 234-8.

The preparation of 2,4-dimethyl-1, 3-pentadiene is described. The boiling point is 93.1-93.2°C., d_4^{20} 0.7368, n_D^{20} 1.4412. Hydrogenation value 100.1% of the theoretical. The hydrogenation product was 2,4-dimethylpentane, the properties of which are given.

Manufacture: Processes and Plant

Chemical Engineering Achievements in Petroleum Refining Editorial. *Chemical and Metallurgical Engineering* **40** (1933) pp. 280-336.

The application of chemical engineering technology and the extensive use of trained chemical engineers has resulted in truly remarkable advances in the technical side of the petroleum industry. The history of cracking and hydrogenation is a case in point. Dewaxing methods are undergoing radical changes with the introduction of "propane dewaxing," special distillation, and "paraflow." Developments in chemical treatment, distillation, and in by-products also illustrate the achievements of chemical engineering.

Twenty-Five Years of Progress In Petroleum Refining. HOWARD W. SHELDON. *American Institute of Chemical Engineers, Silver Anniversary Volume* (1933.)

A historical review of petroleum refining showing growth from 100 refineries in 1908 in contrast with the present developmemnts in drilling, transportation, refining, and by-products illustrates the remarkable advance in this field. The status and extent of research work and its part in the progress of the petroleum industry is reviewed.

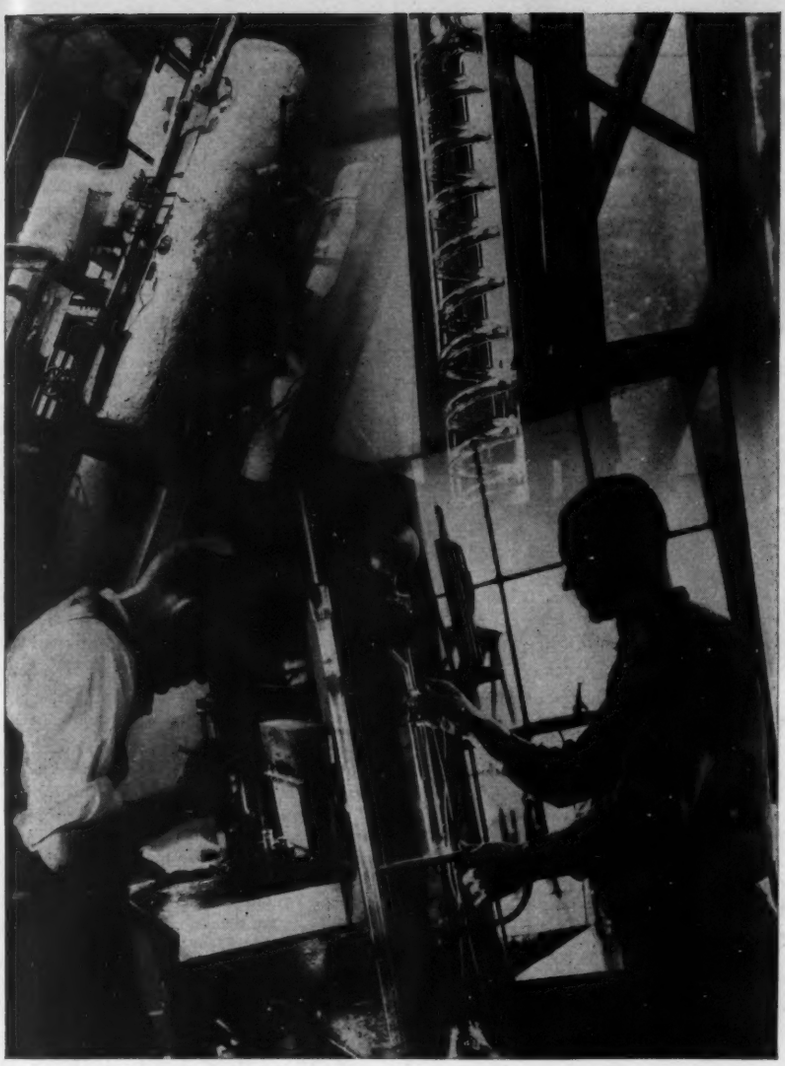
Fractional Distillation Assumes More Important Role Among Chemical Engineering Operations. E. H. LESLIE and H. B. COATES. *Am. Inst. Chem. Eng. Silver Anniversary Volume* (1933) p. 262.

The development of the theoretical as well as the practical side of fractional distillation has progressed rapidly in recent years and has found particular application in the petroleum industry. The more outstanding developments are given in detail. Other industries are also active in applying the principles of fractional distillation. A good example is the use of azeotropic mixtures to produce anhydrous alcohol by fractional distillation.

The Mechanism of Rectification on an Enrichment Plate. E. KIRSCHBAUM. *Z. Ver. deut. Ing.* **77** (1933) 401-2.

The mechanism of the contacting of vapor and liquid on a bubble-cap plate are discussed. Because of the eddies and foaming on the plate, it is possible that the newly generated vapor and the old vapor unite within the liquid layer. However, the principles of partial condensation and formation of new vapor always hold. These conceptions are used as a basis for the calculations of the heat exchanged between vapor and liquid on a given plate. Diagrams for methyl alcohol-water mixtures are given.

A Study of the Refining of Burmah Crude Oil with Special Regard to Color Reversion Characteristics of the



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Lubricating Oil Distillates. A. R BOWEN. *Journal Inst. Pet. Tech.* **19** (1933) pp. 364-75.

The results of a series of experiments in refining Indow crude oil with special reference to the color reversion of the lubricating oil distillates is reported. The less the decomposition in distillation the more stable the oil. The "dark reversion," that is, without oxidation, is the one largely concerned in the reversion of lubricating oil color. Oils darkened by dark reversion are bleached by sunlight or ultra violet light. However, prolonged action causes a darkening through oxidation. Inhibitors are of less value in color reversion caused by polymerization and condensation than in reversion through oxidation. Extractions with solvents concentrates the unstable substances in the extracts. The resinous and asphaltic components in the crude cause color reversion but the overheating of a distillate generates color-reverting substances as well. Use of caustic soda or refining earth in the still yields distillates of good color stability.

Tests for the Fractionation of Low-Boiling Hydrocarbon Mixtures into their Components by means of Silica Gel. H. HOFMEIER and H. MEINER. *Angew. Chem.* **46** (1933) pp. 229-32.

Five commercial silica gels were tested by Grimm's drop method for the fractionation of a light benzine. Only one gel proved to be satisfactory. Using this gel in a small grain size, it was possible to remove half of 10% of aromatics contained in benzine. The gel was spent when 1.5 times its weight of benzine had filtered through it. Unchanged benzine then came through suddenly. To remove adsorbed components from the gel, it was necessary to use high temperature, even up to red heat. This resulted in decomposition of the hydrocarbons and formation of olefines and aromatics. A solution of naphthenes and paraffins could not be fractionated by use of the gel.

Mean Temperature Differences in Multipass Heat Exchangers. W. M. NAGLE. *Ind. Eng. Chem.* **25** (1933) pp. 604-9.

Charts are presented that permit the calculation of mean temperature differences in multipass exchangers by use of correction factors applying to the logarithmic mean temperature difference. The correction factors depend only on the number of passes in the exchanger and on dimensionless ratios involving the inlet and outlet temperatures of the two fluids. Detailed derivations are given for an exchanger having one pass on the shell side and two passes on the tube side and for one having two passes on the shell side and four passes on the tube side. The assumptions involved are those made in deriving the logarithmic mean temperature difference plus that of good mixing of the shell-side fluid.

Heat Transfer from a Horizontal Plate to Boiling Water. M. JAKOB and W. LINKE. *Forsch. Gebiete Ingenieurw. A. or B.* 4, (1933) 75-81.

The heat from a smooth surface to boiling water at atmospheric pressure was measured over wide range of values of total heat transferred. Up to H = 14,200 kg. cal. per sq. m. per hr. The rate follows a power law similar to that applying to natural convection. At values of H above 14,200 it varies according to a power law similar to that applying to forced convection.

Copper as Refining Agent for Petroleum Distillates. G. H. VON FUCHS. *Petr. Zeit.* **29** (1933) (11) pp. 5-8.

Benzine, naphtha, kerosene and other oils were treated with finely divided precipitated cop-

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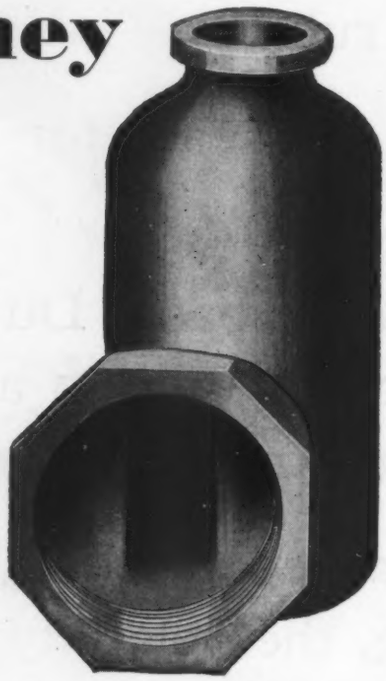

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Products: Properties, Utilization and Testing

Ease of Starting with Benzol, with Petrols, and with Benzol-Petrol Mixtures. W. H. HOFFERT and G. CLAXTON. *Engineering* 135 (1933) 300-302-374-376.

A method of determining ease of starting in terms of number of engine revolutions required to give starting is described. Between 10°C and 20°C benzol gave easier starting than petrol. However, the ease of starting with benzol decreased more rapidly with temperature than the ease of starting with petrol. At below 0°C, petrol exhibits better starting properties than benzol. At temperatures between 0°C. and 10°C. certain blends of benzol and petrol gave easier starting than either benzol or petrol alone. Benzol and benzol-petrol blends showed a wider range of mixture strengths at which starting was possible than did petrol.

Lighter Oil May Mean Cooler Bearings. JAMES I. CLOWER. *Power* 77 (1933) pp. 70-1.

Tests show that two oils of approximately the same viscosity do not offer the same shearing resistance. Also tests in which four oils were studied show that under some operating conditions, a light oil may provide a greater factor of safety against film rupture than a heavier oil.

Iron Content of Used Motor Oils. T. BREITHAUPT. *Petroleum* 29 (1933) No. 7. *Motorenbetr.*, 6, 6-7.

It is considered that the iron content of a motor lubricating oil should be a measure of the wear in the cylinder and should therefore give an indication of the efficiency of lubrication. Tests were made with six oils used in two Mercedes-Benz lorries and showed that the increase in the iron content of the oil per 100 km. run decreased with improved quality of the oil as judged by its viscosity at 100°C. and by heating test.

Why Drain Crankcase Oil? H. C. DICKINSON. *Bureau of Standards Ind. Eng. Chem. New Edition* 11 (1933) No. 12 p. 187.

Crankcase oil serves the dual purpose of cooling and lubricating. The requirements for cooling causes changes during use which in turn are the reasons for oil changes. Deterioration of oil results from (1) dirt, (2) fuel residues, (3) water, (4) metal particles, (5) asphaltenes, (6) cracked products. Each of these is discussed in relation to its influence on oil quality and the need for oil change.

Examination of Candles. P. BRUERE. *Ann. Falsif.*, 26 (1933) pp. 70-74.

Specifications for candles are given as well as methods of examination for appearance, dimensions, average weight, burning time, melting point, acid value, and light intensity. The luminous intensity is measured by comparison with a carbon-filament standard lamp using a photo-electric cell and thermionic amplifier.

Apparatus and Methods for Precise Fractional Distillation Analysis. IV. Standardization of Low Temperature Fractionation Analysis. Apparatus and Method Using Automatic Recording and Control. W. J. PODBIELNIAK. *Ind. Eng. Chem., Anal, Ed.*, 5 (1933) pp. 172-8.

The operation of the Podbielniak apparatus for low temperature fractional distillation analysis of gases and volatile liquids has been improved and rendered 80 to 90% automatic in operation. The robot operator controls reflux cooling, regulates distillation rate to conform to the difficulty of fractionation, summons the human operator by means of a buzzer and trouble light when necessary, takes temperature

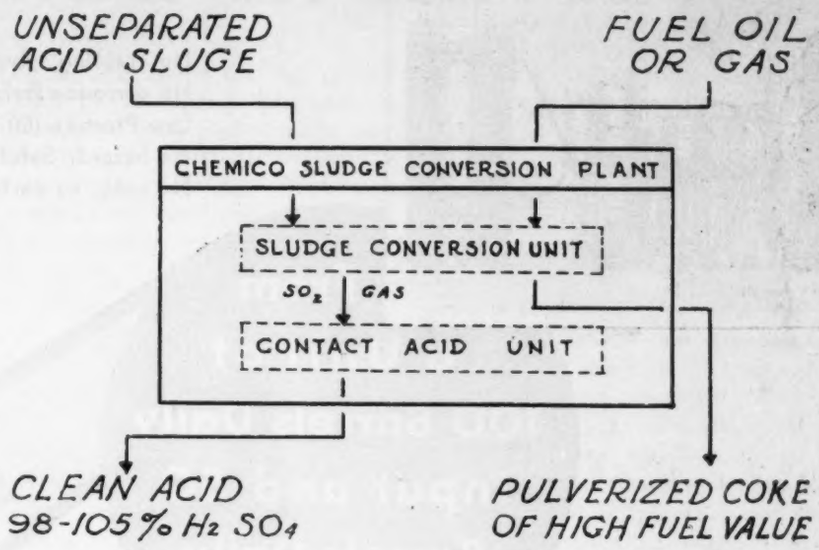
and pressure readings, and prints a distillation curve including a time distillation rate curve.

An Analytical Steam Distillation for Measuring the Volatility Range of Lubricating Oils and other High-Boiling Petroleum Fractions. R. N. J. SAAL and *C. G. Verver. Journal Inst. Pet. Tech.* **19** (1933) pp. 336-63.

Volatility range has rightly come to be regarded as one of the fundamental properties of lubricating oil for internal combustion engines. Also, only those oils that contain a certain proportion of high molecular weight components can form an uninterrupted lubricating film in steam engines using superheated steam. The authors object to the laboratory vacuum distillation methods now in use in some laboratories on the ground that lubricating oils of various origins begin to decompose at temperatures between 320°C. and 350°C., and at 375°C. cracking is very noticeable. The heavier lubricating oils contain hydrocarbons of molecular weights of 600 to 700 and higher. To distill such substances a vacuum of 0.2 mm is required at 350°C. Objections to analytical procedures involving the use of very low pressures are outlined in detail. Heating must be indirect since direct heating involves local overheating. Hence, the authors propose a steam distillation at constant temperature, with the conditions so regulated that (a) substantially complete saturation of the steam with oil vapor is secured, (b) practically no fractional condensation occurs, (c) heating is indirect, by means of a bath of high specific conductivity. The proportion of steam to oil is the measure of volatility. The apparatus and procedure are described. Data are given showing the application of the method to the distillation of a lubricating distillate Penna. bright stock blend and to an oil and the products secured therefrom by SO_2 refining.

The Simplest and Most Accurate Viscosimeter, and other Instruments of Suspended Level. L. UBBELOHDE. *Journal Inst. Pet. Tech.* **19** (1933) pp. 376-420.

An introductory statement calls attention to the unsatisfactory state of viscosity measurement, as well as lack of application of such scientific knowledge as does exist, and emphasizes the importance of the subject in its broad relationship to the as yet unformulated kinetic theory of liquids. In the first section of the paper the principles of capillary measurement, the methods of using relative viscosimeters, and the limits of accuracy of these instruments are reviewed. A new phenomenon, the "suspended level," that offers a simple solution for the problems of viscometry is then described in detail. Theory and experiment show that the suspended level is independent of the variable characteristics of liquids such as viscosity, surface tension, and specific gravity, and that it adjusts itself with physical certainty. Applied to viscometry it has resulted in the development of a new type of instrument of simplicity and pre-eminent accuracy. The correction for kinetic energy, large and yet frequently neglected entirely, is avoided by a new dimensioning that fixes the value once and for all and permits obtaining the kinematic viscosity directly in centistrokes. The conversion of kinematic viscosity into conventional units such as Saybolt, Redwood, or Engler is effected by a table. An instrument for the direct measurement of dynamic viscosity has also been developed. Replacement of the lower liquid surface in instruments for measurement of static capillary rise by the suspended level has resulted in increased accuracy. A new method and apparatus for the measurement of dynamic surface tension has been developed. Other possible applications of the suspended level are being considered.



The advantages of the "CHEMICO" Sludge Conversion Process (Hechenbleikner System) over existing acid recovery systems involving separation of sludge and concentration of the weak separated acid to a black acid containing not over 92% H_2SO_4 are evident from a study of the flow diagram of our process.

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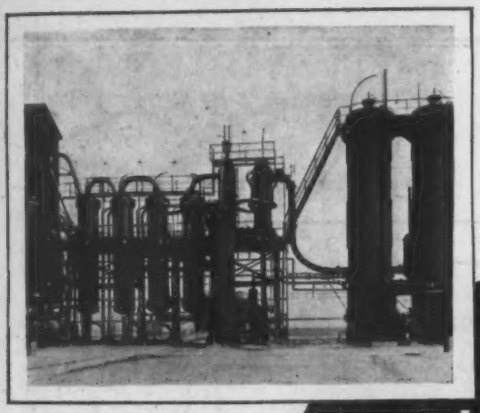

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THE MONTH IN REVIEW

A.P.I. Committee Forecasts Slightly Increased Demand

A SLIGHTLY accelerated demand for motor fuel, counted an indication of improving business conditions, noted in the May study of the American Petroleum Institute's Committee on Refinery Statistics and Economics, looms even larger in the July forecast of that committee made public July 21 by D. J. Moran, chairman of the committee. The committee's report estimates that the total demand for motor fuel for the last six months of 1933 will increase 2.9 per cent over the same period of 1932. In the May forecast it was estimated that the total demand for the middle six months of the year, ending September 30, would represent a decrease of about 3.4 per cent under the same six months of last year.

The reports include the observation that the encouragement of low prices kept consumption of motor fuel at a relatively high point throughout the period of the depression, with only a slight decline in comparison with other commodities.

The forecast of the economic position of the industry with respect to crude oil and motor fuel for the six months' period ending December 31 was compiled from studies made independently by a statistical sub-committee composed of W. A. Sinsheimer, chairman; Fred Van Covern, secretary; W. S. Ackerman, W. C. Allen, O. S. Ambrose, W. B. Case, E. H. Griswold, L. E. Harmon, C. B. Mapes, A. J. McIntosh, E. P. Salisbury, J. M. Sands, and S. A. Swensrud.

Salient points in the forecast and report are:

The daily average requirement for domestic crude oil is estimated to be 2,362,000 barrels, of which 2,262,000 barrels is listed as production, and the remaining 100,000 barrels a reduction in crude oil inventories. The required daily average crude oil run to stills is placed at 2,308,000 barrels.

The total demand for motor fuel will be about 2.9 per cent above the demand for the final six months of 1932, and the domestic demand is expected to increase about three per cent.

Motor fuel stocks on December 31, 1933, should not exceed 46,500,000 barrels, which is a reduction of 7,305,000 barrels from the amount on hand at the close of 1932.

In its estimates the committee has taken into consideration abnormal movements of motor fuel resulting from imposition of federal taxes on gasoline last year and again this year. It is estimated that approximately 5,700,000 barrels in excess of normal were shipped from refineries to consuming centers in May and June of 1932 when the one-cent federal gasoline tax was imminent. These excess stocks were not completely absorbed until the end of the third quarter of the year. When the federal tax was increased to 1½ cents a gallon in June of this year, it is estimated that shipments to distributing plants rose to 2,000,000 barrels above normal. These shipments it is believed will be absorbed during the early months of the present period of forecast.

Demand for crude oil, the report sets out, is considerably below current production, and inventories are increasing at a too rapid rate. The daily demand is estimated to average 2,362,000 barrels for the period, but it is pointed out that requirements will be less during the final quarter of the year. In the matter of motor fuel inventories the committee found that the trend is to-

Details of Forecast of Demand, Economic Stocks and Required Supply of Motor Fuel July 1, 1933—December 31, 1933—By Months

Prepared by American Petroleum Institute's Committee on Refining Statistics and Economics

(In Thousands of Barrels)

		July	August	Sept.	Three Months	Oct.	Nov.	Dec.	Three Months	Six Months 1933	Six Months 1932
Demand	Total	38,500	39,900	36,900	115,300	35,500	33,400	31,200	100,100	215,400	*205,619
	Domestic	36,000	37,500	34,500	108,000	33,000	31,000	29,000	93,000	201,000	*191,436
	Exports	2,500	2,400	2,400	7,300	2,500	2,400	2,200	7,100	14,400	14,183
Stocks	Change during Period	—1,600	—5,150	—3,050	—9,800	—450	+200	+2,050	+1,800	—8,000	—7,753
	Beginning of Period	54,500	52,900	47,750	54,500	44,700	44,250	44,450	44,700	54,500	61,558
	End of Period	52,900	47,750	44,700	44,700	44,250	44,450	46,500	46,500	46,500	53,805
Supply	Total	36,900	34,750	33,850	105,500	35,050	33,600	33,250	101,900	207,400	197,866
	From Imports	—0—	—0—	—0—	—0—	—0—	—0—	—0—	—0—	—0—	575
	From U. S. Producers	36,900	34,750	33,850	105,500	35,050	33,600	33,250	101,900	207,400	197,291
	Straight-run and Crack	34,030	31,950	30,970	96,950	32,020	30,620	30,300	92,940	189,890	179,681
	Natural Gasoline	2,770	2,700	2,780	8,250	2,930	2,880	2,850	8,660	16,910	17,091
	Benzol	100	100	100	300	100	100	100	300	600	519
Probable Straight-run and Cracked Yield		44.5%	44.6%	45.0%	44.7%	45.0%	44.8%	44.5%	44.8%	44.7%	44.8%
Required Crude Runs to Stills—Total		76,472	71,702	68,822	216,996	71,155	68,348	68,090	207,593	424,589	400,839
Daily		2,467	2,313	2,294	2,359	2,295	2,278	2,196	2,256	2,308	2,178

*Figures conform with Bureau of Mines indicated demand. Actual consumption in this period was approximately 5,700,000 barrels in excess of the reported figures which was the result of abnormal shipments having been made in June, 1932 in anticipation of Federal tax.

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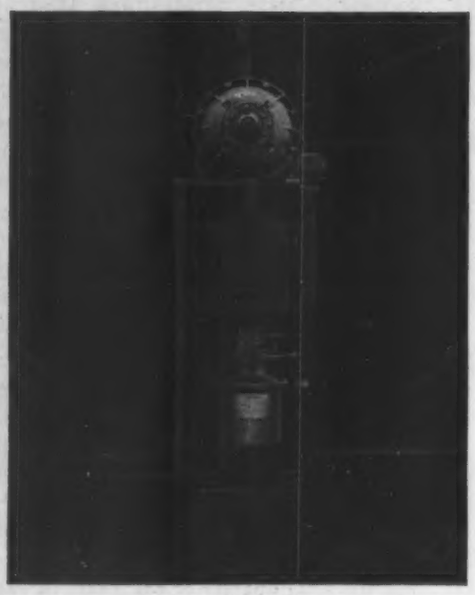

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CONTINUOUS REGENERATIVE COUNTERFLOW

ward economic levels, though current runs to stills are held to be too high, and there is danger of stocks being greater than necessary at the end of the period. The estimate places inventories as of September 30 at 44,700,000 barrels, and at 46,500,000 barrels at the end of the year, representing nominal increases after the end of the peak consuming period.

Petroleum Code Draft Delayed

EFFORTS of the petroleum industry and NRA officials to draft a petroleum code came to a standstill August 3, with disagreement on three major questions. The hearing ended suddenly and representatives of the industry were instructed that a further effort would be made to draft a suitable set of regulations.

—Blank-Stoller Picture.

JAMES A. MOFFETT

This effort is having the attention of Harold L. Ickes, Secretary of the Interior, and James A. Moffett, who became a member of the National Industrial Recovery Board after resigning as senior vice president of Standard Oil Company (New Jersey). He is expected to play a leading role in the administration of whatever control the federal government finally sets up for the petroleum industry.

Perhaps the sharpest division of opinion concerned price fixing. The code draft prepared by NRA officials contained no price regulation. This brought objection from those who held out that it would be unfair to demand maximum hours of labor and minimum rates of pay,

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ANNOUNCE

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without providing also the assurance of funds for meeting this expense.

The controversy over the lease and agency rule of the code drafted in Chicago flared in Washington, when the NRA code ignored the question. General Hugh S. Johnson, administrator, indicated that his body would wait for a ruling from the Federal Trade Commission, where a case is pending. If this body rules the lease and agency an unfair method of competition, the NRA attitude would be to insert that in the petroleum code. Otherwise the question would have to be brought up for further consideration.

A third question was that of allocation of crude oil output between the states. Some state officials were drawn into this, for they held that federal authorities had no control over crude oil production. But the administrator let it be known that the Washington attitude would be not to interfere with production but to halt interstate movement of oil produced in excess of amounts determined in Washington.

Deliberations at Washington found better accord on refining than on any other phase of the industry. A new draft of the refinery provisions was submitted by the committee assigned to that subject. These provisions had not yet received the approval of all interests and were not taken up for discussion. The new draft was as follows:

"Section 1. To achieve greater accuracy in balancing production and consumption, to prevent the injurious effect upon interstate commerce of an unbalanced accumulation of gasoline inventories in any part of the country, and to facilitate equitable access of refineries to the allowable supply of crude oil, the federal agency designated by the President shall divide the country into eight refining districts and shall suggest gasoline production and inventory schedules for each district.

Section 2. The planning and coordinating committee shall appoint subcommittees for each refining district. Said sub-committees shall call the attention of refiners within their respective districts to the existing and recommended gasoline production and gasoline inventories within said districts, and should said refiners fail or refuse to bring their gasoline production and/or inventories within such recommended levels, the federal agency shall exercise its power to allocate gasoline production and inventory among them upon a fair and equitable basis. If any refinery claims that inequities exist in the availability of supplies of crude oil, it shall file complaint with the sub-committee for the district within which it is situated. Said district sub-committee shall immediately endeavor to adjust such controversy; if it cannot do so, it shall without delay refer such complaint to the adjustment committee of the planning and coordination committee, which committee shall receive such complaint for the purpose of making fair and equitable adjustment thereof. In extreme cases, however, where such delays in adjustment referred to are encountered which involves a near approach of a cessation of refinery operations, claimant is privileged to submit its case to the administrator.

"Section 3. Should any refiner have an inadequate supply of crude oil available from current purchases, within economic transportation limits then he may withdraw or purchase from storage such oil as may be necessary to make up the deficiency. In such cases a special report shall be made by such refiner to the subcommittee, which may prohibit further withdrawals by providing the deficiency from current sources at competitive prices. In the event of such purchase from storage then it shall not be an unfair trade practice for the owner of storage oil to make such sale.

"Section 4. During the present emergency the manufacturing, processing or treating of petroleum or its products by any refiner by any process or method which process or method is not equally

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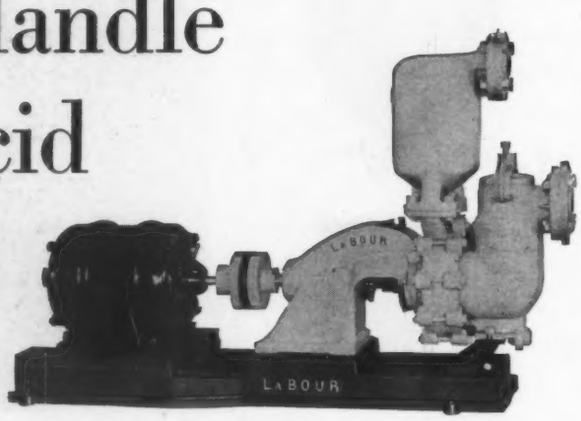

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The simple, rugged design of LaBour pumps makes them reliable. There is but one moving part—the impeller—and there are no valves, floats or other troublesome accessories. Time-out for repairs or replacement is down to the minimum when you use LaBour pumps.

Let the experience of the LaBour organization help you. This organization has long specialized in the problems involved in handling and conveying liquids in process plants. You will be under no obligation or cost in asking for full information.

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open to the use of all refiners shall be deemed unfair practice, and rebates or reciprocal privileges must not be allowed except when open to all other refiners, and the administrative body set up for the enforcement of this code shall formulate such rules and regulations as will secure the enforcement of this provision."

East Texas Refiners Fight "Hot" Oil Order

SOUTHPORT Petroleum Company, Longview, and 48 other East Texas refiners field suit August 3 in the District of Columbia Supreme Court, challenging the constitutionality of the "hot" oil order issued by President Roosevelt last month, and to enjoin Secretary of the Interior Ickes from enforcing such regulations.

An order returnable August 15 was issued, calling for the secretary to show cause why the injunction should not be granted. Preparation of an answer was begun immediately by Charles Fahy, acting solicitor of the department, who is expected to handle the case for the government.

The following campanies and individuals are plaintiffs in the suit:

Southport Petroleum Company, Longview.

Solar Oil Company, Overton.

Oil Refineries, Incorporated, Overton.

McMurray Corporation, Overton.

Gilliland Refining Company, Gladewater.

Carnation Refining Company, Gladewater.

Trinity Refining Company, Gladewater.

Kilgore Refining Company, Gladewater.

Supreme Refining Company, Gladewater.

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Foshel Refining Company, Gladewater.

Lake Refining Company, Gladewater.

Panama Refining Company, Kilgore.

Canyon Refining Company, Kilgore.

Arp Refining Company, Arp.

Big Sandy Oil & Refining Company, Big Sandy.

Niagara Oil Company, Henderson.

Madashell Oil Corporation, Henderson.

Amazon Petroleum Corporation, Henderson.

Double L Oil Company, Tyler.

Century Refining Company, Tyler.

Ortiz Oil Company, Tyler.

McMillan Pipe Line Company, Tyler.

K. W. P. Witt, Charles M. Cops, O. L. Hastings, A. N. Landes, W. C. Turnbow, T. E. Owens, J. Curtis Sanford, Roy Howell, Yandell Rogers, E. J. Bartels, Van R. Hatcher, W. H. Wilson, P. D. Bolen, Karl Dunham, J. M. Lapin, G. A. Franklin, R. S. Harper, T. J. Whitesides, George F. Thaggard and L. B. Manuel, all of Overton.

POWERFUL, SPEEDY, and SILENCED....

Refineries located in residential districts can now use a muffler-equipped Liberty Cleaner for cleaning their still tubes at night, without trouble-making nuisance to surrounding homes.

But this improvement takes second place to the increased speed with which these cleaners handle the job. More powerful motors and better designed cutter heads combine to cut costly minutes off the still tube cleaning operation, to get equipment back into production in minimum time, at maximum efficiency.

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Z-1132

Standardization Work to Continue With ASA

ANNOUNCEMENT by Secretary of Commerce Roper that the simplified practice and industrial standardization work of the Bureau of Standards will be turned over to the American Standards Association has aroused many questions concerning the continuation of this work among groups which have participated in activities of the bureau.

In writing to members of the 37 national technical societies, trade associations and government bureaus which are members of the American Standards Association, President Howard Coonley, of the ASA says, "I am glad to be able to state that provision is being made for assuring continuity on the technical projects. A skeleton staff to be maintained in the discontinued divisions and sections of the bureau during the transition period will greatly facilitate the transfer. Individual projects in standardization and simplification can be carried on without any essential change in method. Plans are now being made for obtaining greater financial aid for the American Standards Association, and when this is accomplished, it is hoped that the ASA may be able to take over a number of the bureau's personnel.

"It is the belief of Secretary Roper, as well as myself, that this transfer will have far-reaching consequences for every branch of American industry concerned with standardization. The effect of the Secretary's decision is to concentrate the responsibility in a single organization representative of industry, the public, and the government. The consolidation of functions in the hands of a single organization is especially important since it comes at a time when the national economy demands sharp acceleration in standards-making to keep pace with the need for industrial agreements under the National Recovery Act.

"We feel that this work is vital to American industry—that the possibilities for joint action opened up by the National Recovery Act will be greatly broadened if industrial and other groups can cooperate in the establishment of a comprehensive system of fundamental technical standards; and we are happy to offer to all of these groups the machinery of the American Standards Association and the Bureau of Standards—now welded into a single unit."

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G-E Turbines Answer the Demands of Oil Refineries

The G-E line of small turbines is complete from 5 hp. and up; single-stage and multistage; condensing and non-condensing for continuous or stand-by service; indoors or outdoors.

And with them, of course, goes General Electric engineering—service in application, installation, and during operation—service that is available now and at any future time.

Write for Bulletin GEA-1145B, on "Steam Turbines for Mechanical Drive." Address the nearest G-E office, or General Electric Company, Dept. 6A-201, Schenectady, N. Y.

175-61

GENERAL ELECTRIC

International Exposition Of Chemical Industries

ONE step toward industrial recovery in the chemical industries was taken some months ago when the date of the Fourteenth International Exposition of Chemical Industries was set, to take place during the week of December 4, 1933. This date was established at a time when the attitude of the nation, industrially and economically, was far less confident than it is today. Now, all signs point to the exposition in December as being most appropriately timed to focus and carry on the advance of the chemical and affiliated industries served.

This year, more than ever before, the exposition of chemical industries provides an opportunity not available elsewhere in the world, for studying the latest designs in a vast array of interesting equipment, and for comparing competitive products side by side. The exhibitors represent over 40 American industries which are classified as chemical.

The exposition will be held in the Grand Central Palace, New York, for which purpose three floors have been set aside. Contracts have been signed which take care of two floors and part of the third. This means that interest in the exposition as at this time expressed by actual contracts, is correspondingly greater than such interest in any previous exposition.

Short Test for Tubular Heat Exchange Equipment

A SHORT test sheet for tubular Heat Exchange Equipment for oil refining service has just been issued by the Petroleum Refining Committee of the American Society of Mechanical Engineers. Last fall the committee issued its "Recommendations for Oil Refining Heat Exchangers" at which time it announced that a shorter test sheet was being prepared.

The recommendations are gradually coming into wide use, according to T. H. Hamilton, chairman of the committee. They were developed as the result of a suggestion made by Walter Samans, Chief Engineer of the Atlantic Refining Company in his paper presented at a meeting of the society in May, 1931.

The recommendations outline a procedure for design, construction practice and testing of heat exchange equipment intended for oil refinery service, and consists of four distinct parts: Part I, emphasizes the data that the refiners should supply to the manufacturers when requesting proposals on heat exchange equipment. Part II, deals with the shop inspection and shop tests for tubular heat exchange equipment. Part III, outlines the specifications for conducting performance test on tubular heat exchange equipment after it has been put into operation. Part IV, the Appendix deals with general subjects as (1) Factors of Design (2) Fouling Resistance, (3) Methods of Cleaning besides general comments concerning the preceding parts of this code.

Equipment Makers Organize for Code

WITH more than 200 oil field and refinery equipment and supply men in attendance, the tentative association of equipment manufacturers to operate under the National Industrial Recovery Act was developed into a permanent association at Dallas August 4, to be known as the American Petroleum Equipment Suppliers Association. By-laws, setting forth the purposes of the organization and its methods of operation were adopted.

A code following the general outline of codes now being drawn up by various trade associations was unanimously adopted Friday night subject to approval of counsel and final acceptance and promulgation by the President of the United States. It was brought out at the meeting that those attending did not wish to be in violation of any state law and that final adherence to the provisions of the codes by its signers would be subject to the understanding that such code would not be held in violation of any federal or state anti-trust laws.

W. L. Childs, general manager of Reed Roller Bit Company, Houston, was unanimously elected president of the association, and Jack Crawford, president of Republic Supply Company of California, was unanimously elected vice president Friday night.

Directors were chosen as follows: California district: Jack Crawford; W. A. Trout, Emsco Derrick & Equipment Company; E. S. Dulin, Byron Jackson Company; Lester H. Keim, Oil Well Supply Company; Dave S. Faulkner, Union Tool Company.

Mid-Continent and Rocky Mountain district: W. J. Morris, Continental Supply Company; Jack Shakely, Frick-Reid Supply Company; Earl Miller, American Iron & Machine Works; Frank Bernsen, Lucey Products Company; A. A. Buschow, Bridgeport Machine & Supply Company; A. A.

GASOLINE YIELD INCREASED 1% *by* TAYLOR DUBL-RESPONSE REGULATOR

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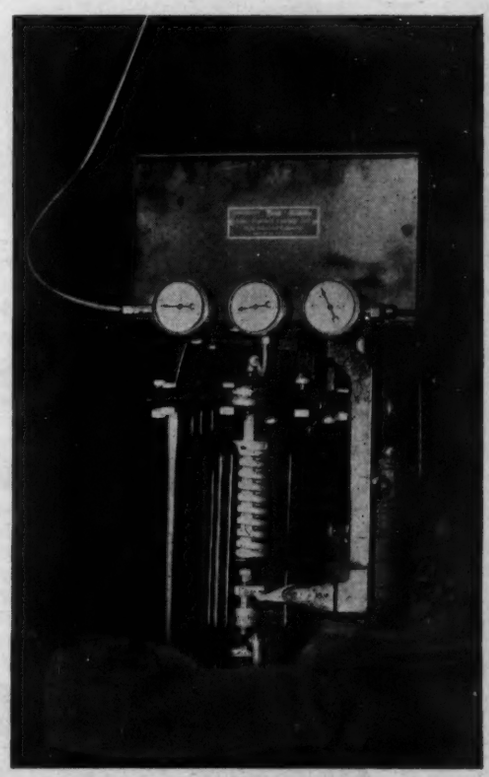
THIS new temperature regulator continues to win new laurels with every installation. In this particular refinery its close, automatic control increased gasoline yield approximately 1% on an average run of 4000 barrels a day, thus effecting an appreciable saving.

The secret behind the Taylor Dubl-Response Regulator is that despite load changes, process time lag, and varying operating conditions, it maintains excellent control of temperature in stabilizers, towers or stills. While each change of load used to change a regulator's setting point and make manual readjustment necessary, now the Dubl-Response Control Unit, the heart of the new Taylor control, corrects for the new condition, and maintains the desired setting point.

Straight line control is a fact. "Hunting" is a thing of the past. Stuffing box friction is overcome. Throttling-valve action is a surety.

This new Taylor Control consists of a Taylor Singl-Duty Recording Regulator and the Dubl-Response Control Unit mounted on a Taylor diaphragm valve. No expert knowledge is necessary to install or maintain the equipment.

Write for the special Taylor Dubl-Response Regulator booklet and let us help you determine how this new development can be applied in your refinery. Address Taylor Instrument Companies, Rochester, N. Y.



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Eastern district: J. A. Geismar, National Supply Company; H. J. Lockhart, Parkersburg Rig & Reel Company; Ben Harris, Oil Well Supply Company; P. C. Jones, The S. M. Jones Company.

Louisiana Standard Announces Promotions

M. J. RATHBONE has been appointed assistant manager, manufacturing department of Standard Oil Company of Louisiana, with headquarters at Baton Rouge. M. W. Boyer succeeds Rathbone as general superintendent of the refinery end and H. J. Voorhies succeeds Boyer in charge of the technical division.

Rathbone joined Standard Oil Company of Louisiana in 1921 as a chemical engineer. He became assistant to the general superintendent in 1926 and in 1931 was appointed general superintendent of the refinery.

Boyer joined the organization as a chemical engineer in 1927, becoming chief chemical engineer in 1930 and in 1931 was made head of the technical division. Voorhies entered the employ of the company in 1922 and was engaged for several years in the steam, water and gas department, and was placed in charge of process engineers in May of this year.

ROBERT E. TRIMBLE has been named assistant sales manager of the Warner-Quinlan Company, New York. He came to the concern following the selection of L. V. Nicholas as president. Mr. Trimble was one of the officials of the Western Oil Company of Indianapolis, which was sold to Shell Petroleum Corporation in 1929.

CRUDE oil prices were made uniform in the Mid-Continent early in August when Sinclair Prairie Crude Oil Purchasing Company dropped its price on East Texas oil to 50 cents a barrel. There had been an uneven price schedule for the Mid-Continent since mid-June when price advances were announced but not generally followed.

"Hot" Oil Rules Modified

REGULATIONS of the Department of the Interior concerning the movement of oil interstate were amended early in August so that the stringent parts of the orders apply only to the East Texas and the Oklahoma City pools.

After President Roosevelt issued the executive order banning interstate shipment of oil illegally produced, the Secretary of the Interior issued regulations for oil producers of the United States to follow in making regular reports. But there has been so little complaint from fields other than the two above that changes were made in keeping with current conditions.

Ethyl Gasoline Price Reduced

REDUCTIONS in the cost of tetra ethyl lead by Ethyl Gasoline Corporation were made early in August to allow the users of this material to make a reduction of one cent per gallon in Ethyl gasoline. The concerns marketing this gasoline announced the reduction August 1.

Frick Type J Compressor at Bayonne, N. J. plant of Tidewater Oil Co.

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PLANT ACTIVITIES

Gasoline Plant: Gregg-Texas Gasoline Corporation erecting 24,000-gallon compression and rectifying column type natural gasoline plant at Willow Springs, East Texas field. Contract to Petroleum Engineering, Inc., associated with Arthur G. McKee Company. Reported cost $225,000. K. E. Jones, Shreveport, has been named active head of the company and Clark Sample, Longview, agent in the construction of the plant.

Gasoline Plant: Hagy, Harrison & Marsh, Amarillo, building 60,000,000-foot gasoline plant near Pampa, Texas, (Panhandle), with Phillips Petroleum Company engineering department in charge of construction.

Crude Unit: Sloan & Zook Refining Company, Warren, Pa., let contract to Alco Products, Inc., for new 1500-barrel distillation unit at the recently acquired Swan-Finch refinery.

Gasoline Plant: Shamrock Oil & Gas Company, erecting 40,000,000-cubic foot absorption natural gasoline plant near Dumas, Moore County, Texas, (Panhandle), well pressure type, contract to Stearns Rogers Manufacturing Company, technical supervision by Parkhill-Wade. Inc. Same company's well pressure plant near Lefors, Gray County, is being equipped with compressors.

Refinery: Shamrock Oil & Gas Company, Amarillo, Texas, building 1200-barrel skimming plant, to operate on Gray County crude, located at Davis Switch, near Lefors, on Fort Worth & Denver Railroad.

Lube Plant: Union Oil Company, Los Angeles, plans erection of addition to lubricating oil plant at Oleum. Contract for tankage to Berkeley Steel Construction Company. Estimated cost $500,000.

Road Oil Plant: New Mexico Road Oil Company, formed by J. H. Jackson, Lillian Phelps and J. C. Jackson, will take over old Sullivan refinery at Dayton, New Mexico, to manufacture road oil from crude from the Getty pool.

Purchase: Sinclair Refining Company purchased from Barnsdall Oil Company three per cent interest in Great Lakes pipe Line Company, gasoline line from Oklahoma to Middle-West points. Present owners in the pipe line, in addition to this company, include The Texas Company, Continental Oil Company, Phillips Petroleum Company, Skelly Oil Company, Pure Oil Company and Mid-Continent Petroleum Corporation.

Steam Plant: Phillips Petroleum Company, Kansas City, Kansas, installing two steam generating units, multiple circuit bent tube design, all welded construction, contract to Henry Vogt Company.

Alkali Plant: Southern Alkali Corporation, Avery Point, Nueces Bay, Corpus Christi, Texas, building $6,000,000 plant to produce soda ash, caustic soda and allied products. H. K. Ferguson Company, Hanna Building, Clevelan, construction engineers, O. N. Stevens, company official in charge at Corpus Christi.

Operating: Independent Oil & Refining Company, Laurel, Montana, (formerly Laurel Oil & Refining Company), has resumed operation after remodeling, running 3000 barrels Oregon Basin and Dry Creek crudes.

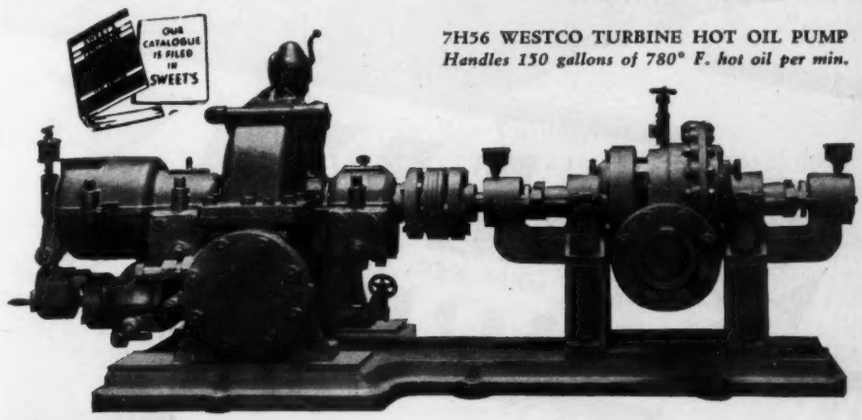
Cracking Units: Sparton Refining Company, Jewella, (Shreveport), Louisiana, contract to Alco Products, Inc., two Gyro Cracking Units (7500 barrels total capacity), and a single gas and polymerization system, supplanting older cracking facilities. Atlas Pipe Line Company, parent company, capacity, crude 10,000 barrels. Headquarters in recently purchased Soady Building, Shreveport.

Refinery: A. S. Everest, H. Hall, and Foy Born, Paducah, Texas, plan erection of a 500-barrel skimming plant, to market gasoline, kerosene and fuel oil locally and in near by towns.

Operating: North Texas Oil & Refining Company, completed 200-barrel skimming plant two miles south of Wichita Falls. W. E. Johnson, T. S. Smith, and Walter Nelson, Jr., owners.

Operating: Century Refining Company, formed by Ortiz Oil Company, Wichita Falls, to operate 2500-barrel skimming plant at Friars Switch, East Texas, began operation July 8. C. A. Middleton, general manager, with offices Reeves Building, Tyler, Texas.

Cracking: Trio Refining Corporation, Shreveport, Louisiana, acquired Reese Refining Company's 1000-barrel skimming plant, Arp, East Texas field, and ordered plant remodeled and cracking unit erected. M. J. Grogan, B. P.



7H56 WESTCO TURBINE HOT OIL PUMP
Handles 150 gallons of 780° F. hot oil per min.

BEATS HIGH TEMPERATURES AT THEIR OWN GAME

WESTCO TURBINE HOT OIL PUMP allows full play to expansion and contraction

TWO recent improvements make this valuable feature possible. They are:

1. Symmetrical design of pump
2. New type expansion mounting

Improvement No. 1 eliminates the hazards of uneven expansion and contraction, which ordinarily cause strain and stress. Improvement No. 2 is an ingenious mounting that does not restrict expansion and contraction in the pump itself. This is accomplished without sacrificing alignment of pump and turbine or motor.

Does Not Vapor Bind

A non-pulsating flow is assured at all times. The pump cannot become vapor bound! And here's another "beautiful" feature:—the water-jacketed stuffing boxes are definitely relieved of pressure. Packing in a Westco lasts and lasts— because the oil is cooled before it ever touches the packing.

Corrosion-resisting Construction

Impeller and shaft are made of Stainless Steel. Casings are made of cast steel. However, these pumps can be furnished entirely of Stainless Steel, or other alloys, if a complete corrosion-resisting unit is required. Westco's ability to produce higher pressures in single stage avoids a good deal of costly multi-stage construction.

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WESTCO *TURBINE* PUMPS
HIGH PRESSURE - - - SINGLE STAGE

Crittenden and associates, organizers and owners.

Purchase: Roger Lacey, East Texas producer and refiner, Longview, Texas, and G. C. Allen et al have acquired inactive 500-barrel skimming plant at Memphis, Tenn., to recondition and operate on tank car shipments of East Texas crude.

Purchase: Lawrence Gasoline Plant, Inc., headquarters Republic National Bank Building, Dallas, formed by Harry Ginsburg, J. C. Pundt, et al, to operate gasoline plant at Kilgore, East Texas field, which was moved from Camps Switch early in July. B. F. Lawrence, president, C. A. Parker, superintendent.

Operating: Magnolia Petroleum Company, resumed operations late in July of its Plant No. 2 (formerly White Eagle Oil & Refining Company) at Fort Worth, Texas, topping only, residues piped to Plant No. 1, equipped with modern cracking facilities.

Modernization: Gulf Refining Company, Port Arthur, Texas, started work modernizing and revamping several cracking units. Reported major expansion program indefinitely deferred.

Stabilization: The Texas Company, Port Arthur, Texas, plans installation of new gasoline recovery plant and stabilization system.

Recovery Unit: Louisiana Oil Refining Corporation, Shreveport, plans installation of new gasoline recovery and stabilization system and reported planning modernization of its cracking department, indefinite maturity.

Recovery Unit: Crown Oil & Refining Company, Houston, planning erection of new gasoline recovery unit, absorption type.

Lease Plant: Fox Refining Company, headed by C. H. Fox, has leased the Garber, Oklahoma, plant of Garber Refinery, Inc., for three years, to operate August 15.

Agreement: Gray Processes Corporation has entered into licensing agreements with The Texas Company, Standard Oil Company (Indiana), Pure Oil Company and Standard Oil Development Company whereby these companies acquire licenses to use the Gray process on a lump sum royalty basis and Gray Processes Corporation obtains the right to grant licenses under the clay treating patents of the four oil companies.

Cracking Unit: Cedar Grove Refining Company, Shreveport, Louisiana, let contract to Emil Geppelt, Jr., for construction of 600-barrel cracking unit at its Cedar Grove plant.

Gasoline Lines: Sinclair Refining Company will connect its refineries at Sand Springs, Oklahoma, and Coffeyville, Kansas, to Great Lakes Pipe Line Company's gasoline lines, following purchase of three per cent interest. Includes new line pipe and pumping facilities.

Distillation Unit: Canfield Oil Company, Coraopolis, Pa., in addition to new 1200-barrel crude distillation unit will build unit for production of light distillate specialties; contract to Alco Products, Inc.

Reorganization: W. P. Andrews Oil Company, reorganized, has disposed of the Newhall, California plant to J. A. Moffett, a former officer of the company. Mr. Andrews remains in control of the concern with its refinery at Signal Hill, where he has established headquarters offices.

Hydrogenation Unit: Imperial Chemical Industries, Ltd. (part owner of the world hydrogenation patents with Standard Oil Company (New Jersey) and I. G. Farbenindustrie) to erect $12,000,000 hydrogenation plant near Middlesborough, England, to produce gasoline and other products from coal. Government has given minimum preference of eight cents per gallon in favor of gasoline manufactured from British coal for 10 years, effective April 1, 1934.

Improve: Hancock Oil Company, Long Beach, Calif., has enlarged capacity through installation of new high pressure heat exchange equipment and large condenser. Contract to Southwestern Engineering Corporation.

Improve: Lakeside Oil & Refining Company, Maricopa, Calif., has installed a 52-foot Southwestern Engineering Corporation fractionating column.

Refinery: Suburbon Oil Service, Inc., Mt. Vernon, New York, reported planning erection of skimming plant on Houston ship channel. W. K. Kirby, Houston, is consultant in construction.

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58% Soda Ash
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Solid—Flake—Ground—Liquid
Leading refiners depend on these products for the quality and uniformity which industry inevitably associates with the name Solvay. First in pioneering the development of American sources of alkali, The Solvay Process Company is recognized as the outstanding leader of its field—first in size and first in facilities for rendering efficient service.
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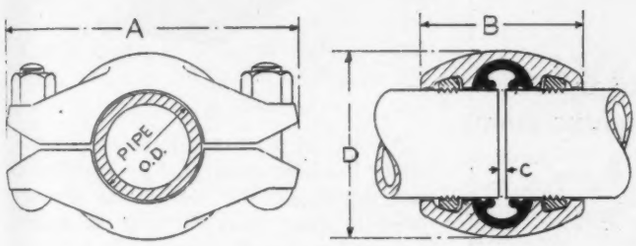
Alkalies and Chemical Products Manufactured by
The Solvay Process Company
New York
61 Broadway

New Equipment for the Modern Plant

1. Pipe Coupling

THE CONTINENTAL SUPPLY COMPANY

The Continental Supply Company, St. Louis, Missouri, announces the "Champion" positive seal, drop forged pipe coupling, developed to facilitate the laying of pipe lines by use of straight plain-end pipe which has not been subjected to an extra finishing operation, such as grooving or upsetting the ends.



Champion Pipe Coupling

The coupling consists of five parts: two half couplings which contain the grippers, one gasket with metal protected sections, and two bolts. Gripping rings are drop forged and heat treated to form a hard, tough section and are assembled to become integral with the coupling. The bolts are heat treated to provide a high elastic limit, but retain a sufficient degree of elasticity to prevent any breakage, according to the manufacturer. The nuts are heavier than the standard nut for the same size bolt.

Gaskets are designed along the line of the low pressure automobile tire with a double seal effective against pressure or vacuum, and tested up to 4000 pounds pressure.

2. Gear Box for Threading Machines

LANDIS MACHINE COMPANY, INC.

Landis Machine Company, Incorporated, Waynesboro, Pennsylvania, has developed a new selective speed gear box for use on its motor driven two-inch pipe threading and cutting machine, two-inch pipe and nipple threading machine and the two-inch and two and one-half-inch bolt threading machines.

This gear box has eight speeds. The speed changes are effected through self-locking levers which are conveniently located and easily operated. The lever positions for the various speeds are indicated by a speed plate attached to the gear box cover.

This unit is self-contained and completely enclosed. There are no unguarded moving parts nor are there any openings to the interior of the gear box. All gears are cut from chrome nickel steel and are hardened and burnished. The gear shafting, which is made of heat treated alloy steel, is mounted on anti-friction bearings. Both gears and bearings are lubricated automatically by a splash system from an oil reservoir formed in the lower portion of the gear case.

The selective speed gear box can be bolted on to the head stock in the same position as the tumbler gear box or the speed reducing plate used as standard equipment on the constant speed and variable speed motor driven machines, respectively. The new gear box is recommended with either A.C. or D. C. constant speed motors wound for an approximate speed of 1200 R.P.M.

3. Dry Chemical Feeder

INTERNATIONAL FILTER COMPANY

International Filter Company, 59 East Van Buren Street, Chicago, has introduced a new Infilco No. 8 dry chemical feeder for accurate volumetric measurement of dry powders or granular materials. The machine is designed to handle quantities from a fraction of a pound per hour to 150 pounds per hour. Mechanism consists of an adjustable knife fitted in a stationary ring which cuts off a section of a revolving cylinder of the material contained in a revolving drum on a revolving table. During each revolution a definite quantity is cut off by the knife and discharged from the edge of the table. It is said that a large number of these feeders have recently been installed for water treating purposes for feeding of powdered carbon, hydrated lime, alum and the like.

4. Combination Valve

SNETCHER & PITTMAN

Snetcher & Pittman, Oklahoma City, Oklahoma, announce the new Hallett combination globe and check valve which they will manufacture and distribute. The advantage of this valve lies in its ability to serve both as a globe valve or check valve. It has a removable seat, large stuffing box in the upper part of a one-piece screw-over bonnett, strong shank and guide, slightly open for check valve, open position for globe valve. Construction is of bronze.

5. Thermometer

C. J. TAGLIABUE MANUFACTURING COMPANY

C. J. Tagliabue Manufacturing Company, Park and Nostrand Avenues, Brooklyn, N. Y., announces a new five-inch dial indicating thermometer in a black bakelite case. This instrument was developed for manufacturers who demand a moderately priced dial thermometer that stands up under severe operating conditions.

TAG Thermometer

The TAG Dial Thermometer is in every respect a first quality, accurate temperature indicator, with an exceptionally powerful moving element or

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REFINER AND NATURAL GASOLINE MANUFACTURER,
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Company . . . . . .

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handle BOTH *pipe and fittings*

Here is the unbeatable tongs for Refinery use.

"Vulcan Superior" is a universal service tongs for both pipe and fittings —TWO tools in one. You can switch from one to the other *instantly*— no parts to change, no adjustments to make.

Seven sizes, with either flat link or cable chain, handle pipe and fittings from ⅛ to 12 inches. Fully guaranteed. Ask your supplier to show you this extra value tongs today. Literature on request.

J. H. WILLIAMS & CO.
"The Wrench People"
75 Spring St. New York
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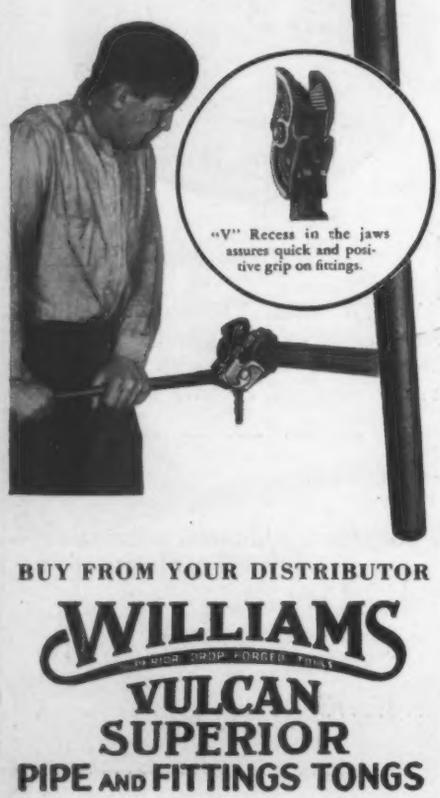

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WILLIAMS
VULCAN SUPERIOR
PIPE AND FITTINGS TONGS

bellows suited to certain commonly used vapor tension ranges between minus 40 and plus 335°F.

The indicating pointer is actuated by the motion of a bronze bellows which expand and contract at the slightest temperature change at the bulb. This powerful motion is transmitted directly to the pointer by a new vibration-proof connecting mechanism.

Strikingly neat in appearance, the black bakelite case serves as a perfect contrast for the large clear-cut white numerals of the jet black five-inch dial. With the instrument case mounted at a convenient distance to face the operators, the pointer of the thermometer can be read as easily and surely as the hands of a clock.

6. Steam Generator

COMBUSTION ENGINEERING CORP.

Combustion Engineering Corporation, 200 Madison Avenue, New York, announce a new standard design of steam generating unit for capacities from 8,000 to 40,000 pounds of steam per hour. Compactness of this small generating unit and economy in cost are featured. The unit requires low head room and small floor space, and may be fired with pulverized fuel, oil or gas.

7. Motor Operated Controller

AUTOMATIC TEMPERATURE CONTROL COMPANY

Automatic Temperature Control Company, Philadelphia, announces addition of the new Type 2 Controller to meet the demand for a sturdy but inexpensive two-position controller. The device is supplied to operate valves of the globe type in sizes up to three-inch and for pressures up to 250 pounds. For lower pressures the controller has sufficient power to handle larger globe valves. In combustion control work the motor will handle an air valve up to four-inch in combination with a half-inch fuel oil valve.

8. Controllers

THE BRISTOL COMPANY

The Bristol Company, Waterbury, Connecticut, announces a new line of time temperature and time pressure controllers for use in processes where it is desired to regulate a temperature or pressure at some fixed rate and then hold it or decrease it at some other rate. The instruments are designed for operation on any range of temperature from minus 40 to 1000° F., or pressure from 10 to 2,000 pounds.

9. Fractional Horsepower Motor

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, announces a new single-phase, fractional horsepower motor, specially designed for driving small water pumps.

G-E Motor

Among the features of the new motor, which has been designated as Type RSA, are drip-proof end flanges to prevent dripping water from entering the motor, a large bearing-oil capacity which makes oiling of the motor unnecessary more than once a year, and a built-in terminal box for simplifying installation by eliminating all necessity for splicing and soldering connections.

Performance characteristics of the motor are in accordance with N.E.M.A. standards for short annual service. The motor is available in one-sixth, one-quarter, and one-third horsepower ratings, with interchangeable mounting dimensions.

10. Carbon Dioxide Recorder-Indicator

THE HAYS CORPORATION

The Hays Corporation, Michigan City, Indiana, announces a new Hays CO_2 Recorder-Indicator which operates on the Orstat principle. A continuous stream of flue gas is drawn rapidly from the last pass of the boiler. At regular intervals the machine takes a measured sample, causes the CO_2 to be absorbed and the pen to record the amount of the absorption, or in other words, the CO_2 content. At the same time the pointer indicates the per cent of CO_2 on a large scale clearly visible at any normal distance. The pen and pointer hold their position after each analysis and change this position only when a change in the CO_2 content of the waste gases occurs.

Hays CO_2 Recorder-Indicators are also offered with a record of overfire draft and flue gas temperature on the same 10-inch chart along with the CO_2 record.

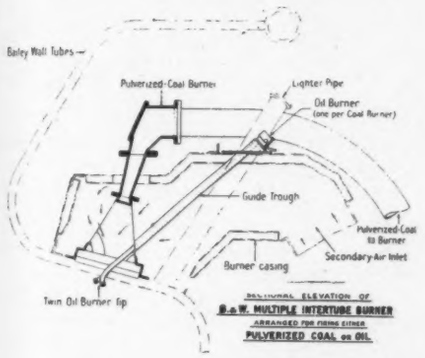
Remote mounting results in practically no lag since the CO_2 analyzer section is placed at the most convenient location

as close as possible to the point where the soot filter extends into the last pass of the boiler. The Recorder-Indicator is located at the front of the boiler to guide the fireman toward attainment of highest possible combustion efficiency. A loom lagged 3/16-inch copper tube connects the CO_2 analyzer section to the recorder section. Transmission is accomplished pneumatically in a positive, dependable and trouble-free manner.

11. Combination Burners

THE BABCOCK & WILCOX CO.

The Babcock & Wilcox Company announces a combination pulverized-coal and oil burner which successfully meets the requirements of such an installation in water-cooled furnace walls. Its construction is shown by the accompanying figure from which it will be noticed that the pulverized-coal burner is the standard B & W Multiple Intertube Burner. The oil burner is of the twin-nozzle type and is inserted between two tubes in front of the pulverized-coal burner, extending back and through the burner casing, supported by a guide trough between the casing and the burner tip. The oil-burner tips are set so that the oil is distributed across the air stream to obtain a satisfactory mixture of fuel and air.



12. Cement Lined Pipe

NATIONAL TUBE COMPANY

National Tube Company, Pittsburgh, after exhaustive research has developed a special corrosion resistant lining for pipe known as "Duroline." The new lining is said to have only about one-third of the solubility of ordinary portland cement mixtures. The pipe used is the same quality as this company's regular black or galvanized wrought pipe. Lining is accomplished with a method of curing involving the use of moist air, steam and hot and cold water treatment extending over a period of several days. The pipe is primarily intended for carrying waters which rust, corrode and otherwise attack unprotected metal pipe. The lining is said to be resistant to salt water and many dilute chemical solutions.

13. Air Charging Devices

BYRON JACKSON MANUFACTURING COMPANY

Byron Jackson Manufacturing Company, Berkeley, California, announces, in the general application of centrifugal pumps in connection with automatic pressure systems, application of a simple air charger in place of an air compressor for keeping the pressure tank supplied with air.

The manufacturer claims the air charger operates at every stop and that it starts automatically by the pressure water from the pump, and that it supplies a somewhat greater amount of air than necessary to keep the tank charged, the excess air being vented by an air relief valve.

14. Flexible Tank Roof Seal

THIOKOL CORPORATION

Thiokol Corporation, Yardville, New Jersey, announces "Thiokol," a rubber substitute as a flexible seal for floating roofs on oil tanks, which has been adopted by the Chicago Bridge and Iron Works, Chicago, Illinois.

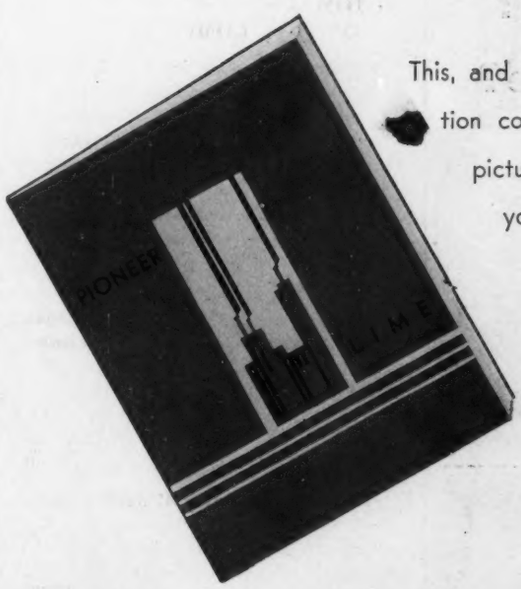
The seal consists of a circular band of steel shoes connected to each other and to the top of the rim plate with a fabric impregnated with Thiokol. Hangers from the deck keep them in parallel contact with the tank shell.

It was to overcome the difficulties arising from the use of the sour crudes that the seal was developed.

We are not satisfied

with the mere selling of either a small or large order of lime to any oil refinery. Regardless of the amount of PIONEER OYSTER-SHELL LIME you buy, or the use to which you put it, we want it to serve you efficiently.

That is why we have so carefully studied and classified its chemical and physical properties, and their correct application to sixteen fundamental oil refining operations.



This, and other valuable information contained in the booklet pictured herewith, will help you to secure the full benefits of PIONEER'S superior quality. A copy is yours for the asking.

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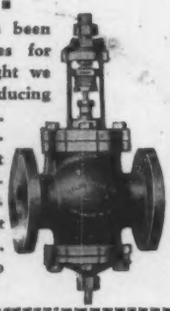

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- ☐ The Campbell Boiler Feed Water Regulator
- ☐ Reducing Valves
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- ☐ Swing Joint Fittings
- ☐ Bronze Unions
- ☐ Thermostats
- ☐ Balanced Valves
- ☐ Control Valves

Items About Manufacturers

Hanlon-Waters, Inc., of Tulsa, will begin manufacturing in Tulsa immediately a complete line of automatic equipment such as liquid level controls, level valves, motor valves, pressure reducing valves, back pressure valves, relief valves, etc., especially designed for the petroleum refinery and natural gasoline industry. Hanlon-Waters have for many years been selling equipment to this trade and have been manufacturing certain items of oil country equipment such as separators and bolted tanks.

"We have been engaged in the sale and application of automatic equipment used in the refining and natural gasoline business for a number of years and will bring into our manufacturing unit what we believe to be a wealth of information which should be most valuable to concerns who are desirous of having actual engineering experience and study applied to such equipment," M. F. Waters said in announcing the new manufacturing enterprise.

The new equipment will be sold either direct or through supply stores and jobbers.

Western Sand-Banum Company, distributors of Standard Boiler Sand-Banum for treatment of boiler scale, priming, foaming and for the elimination and prevention of boiler scale, is now made up of three territorial units, the Gulf Coast, Rocky Mountain States, and the Pacific Coast. Gulf Coast headquarters, originally organized by Frank J. Welu in 1932, is located at 703 Merchans' & Manufacturers' Building, Houston. The territory was expanded by Mr. Welu, who has placed J. E. Barber in Denver, Colorado, with offices at 1670 Cherry Street, as manager of that district, and H. M. Sanford in San Francisco, with offices at 1770 Broadway, in charge of the California, Oregon and Washington division.

Western Sand-Banum Company is an affiliated company of American Sand-Banum Company, Inc., 342 Madison Avenue, New York, which recently has completed plans for building an American factory in Brooklyn. American Sand-Banum Company, Inc., was organized as the American division of International Sand-Banum Syndicate, of Berlin, Germany.

Standard Sand-Banum is distributed in pint cans, one pint treating a 250 horsepower boiler for 30 days, while Emulsion Sand-Banum is distributed in quart cans, for cold water treatment, one quart being used to treat 100,000 gallons of make-up water for one year.

Moorlane Company of Tulsa, Oklahoma, has established branch offices at Houston at 322 M. & M. Building. E. L. MacBlain is district manager and A. T. Crump, office and warehouse manager.

The Industrial Chemical Sales Company, 250 Park Avenue, New York, manufacturers of Nuchar activated carbons, have opened branch offices at 370 West Broad Street, Columbus, Ohio, with R. N. Statham, formerly assistant manager of the company's Chicago office in charge.

Fisher Governor Company, Marshalltown, Iowa, has appointed M. N. Dannenbaum Company, 304 Shell Building, Houston, Texas, as the direct factory representative in Southern and Eastern Texas.

Thiokol Corporation, Yardville, Trenton, N. J., announces that through an arrangement recently consumated with the Monsanto Chemical Work, Ltd., of London, England, "Thiokol" will be made available for sale and distribution in Europe.

Allis-Chalmers Manufacturing Company, Milwaukee, announced that L. W. Grothaus has been appointed assistant to the president, being promoted to this position from that of general representative. Walter Geist, inventor of the company's "Texrope Drive" has been appointed general representative, succeeding Mr. Grothaus.

The Babcock & Wilcox Company, Beaver Falls, Pa., has appointed T. F. Thornton as its sales manager in the Detroit district.

General American Tank Car Corporation, Chicago, at its annual meeting voted to change the name of the company to General American Transportation Corporation.

Mason Regulator Company, Boston, manufacturers of automatic regulating and control equipment, and Neilan Company, Ltd., Los Angeles (a subsidiary) have consolidated. The name of the new company is Mason-Neilan Regulator Company. Engineering, manufacturing and sales departments of the individual companies have been combined and are located at 1190 Adams Street, Boston. F. K. Morrison, former sales manager for Mason Regulator Company will continue in same position for the new company. D. H. Annin, chief engineer for Neilan Company, will serve in the same capacity for the new concern.

Erie Bolt & Nut Company, Erie, Pennsylvania, announces appointment of Moorlane Company as distributors at Houston and Tulsa where complete lines are carried in stock.

Metal & Thermit Corporation, 120 Broadway, New York, announces it has opened a warehouse at 802 East Archer Street, Tulsa, Oklahoma, with Joseph Hodges in charge. A complete stock of Murex welding electrodes will be carried at Tulsa.

Homestead Valve Manufacturing Company, Incorporated, Coraopolis, Pennsylvania, has appointed Reeves-McCormick, Inc., 5317 North Second Street, Philadelphia, Pennsylvania, as exclusive representative covering the Philadelphia district, for the sale of "Hypressure Jenny" a vapor spray machine.

T. J. (Tommy) Robinson is now with Continental Supply Company, working out of the Houston office calling on petroleum refineries and other industrial concerns as district salesman for the Gulf Coast refining district.

Paul T. Putnam, formerly oil field salesman for the W-K-M Company, Inc., and Cameron Iron Works, and who for several years wrote oil field advertising for Houston advertising agency, has joined the staff of the Gulf Publishing Company. He will assume the field work formerly handled by J. D. (Eb) Isaacks, who resigned recently to represent Kerotest Valve Company.